The
ENGINEERS' DIGEST
A World Review of
DESIGN & PRODUCTION · RESEARCH & DEVELOPMENT
VOL. XXI No. 4 APRIL, 1960

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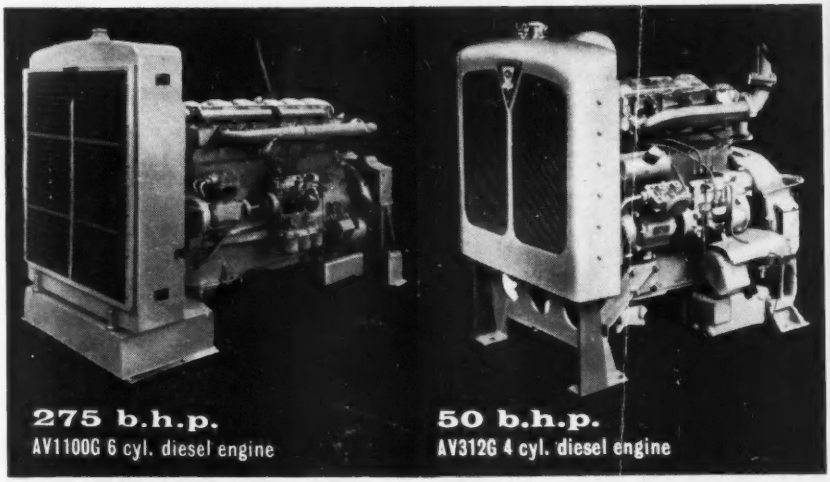

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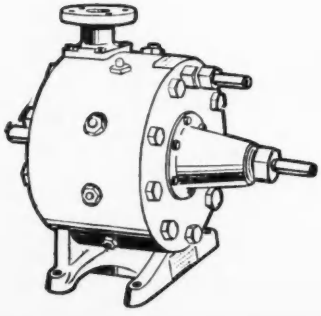

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2½" dia.	Tempered 600°C	47.4	55.6	22	75
1½" dia.		50.8	59.2	21.5	59

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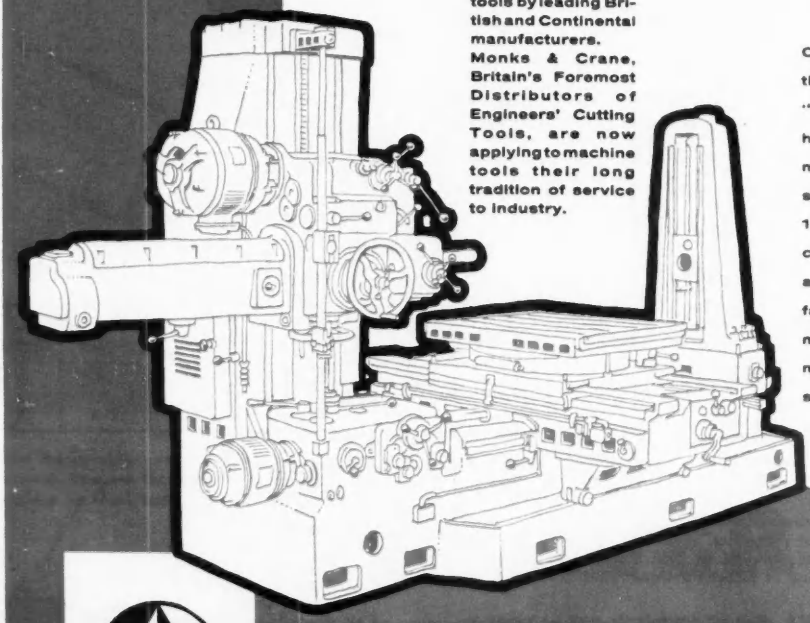

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A World Review of DESIGN & PRODUCTION · RESEARCH & DEVELOPMENT

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Utilizing a "bouncing-light" principle, a **new sight-gauge for indicating liquid level,** developed by Seirra-Schroeder Controls Division, of Glendale, Cal., U.S.A., and reported in *Machine Design* for January 21, 1960, incorporates a plastic slip-tube in the bottom of the vessel and a prism at the opposite end of an inner plastic tube. Incident light passes through a viewer window in the base of the slip-tube and is transmitted through the inner plastic tube to the prism. If the prism is out of the liquid, it concentrates and reflects the light, illuminating the interior of the tube. When the top of the tube is moved down into the liquid and the prism is submerged, the light in the prism is absorbed by the liquid, and the inside of the tube becomes dark.

* * *

A **multi-spark light source** capable of producing high-intensity light of 10^{-7} sec duration for any preset time interval of 10^{-5} sec or more has been developed by the Cornell Aeronautical Laboratory in the U.S.A. Primarily intended for studying ballistics, flutter, vibration, and the motion of bodies in confined spaces, the system is based on the extremely short light flash obtained by discharging a capacitor through a spark-gap. The equipment actually in use employs five spark-source assemblies, each with a barium titanate capacitor, mounted in series and separated by lens systems, the capacitors being triggered by a pressure pulse and set to discharge at different times. The discharge across the spark-gap, which is powered by a 10,000-V source, focuses light on a prism, providing sufficient illumination on the subject to expose the film in a drum-camera.

* * *

In an article in the Russian journal *Stal* for January 1960, it is claimed that, by using an **alternating-current electrolytic pickling method,** it is possible to obtain a considerable increase in the efficiency of pickling operations, combined with a reduction in the consumption of electrical energy and chemicals. In this process, cold- or hot-rolled steel sheet is passed through a 0·5 to 0·7N hydrochloric acid bath between graphite electrodes, 70 mm apart, supplied with an alternating current of 50 cps at a voltage of from 2·8 to 5·5 V and a current density of from 4 to 9 A/dm². The sheet is not in actual contact with the electrodes. It is stated that the use of alternating current ensures that the formation of

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The MINIDIGEST

chlorine on the surface of the sheet—a considerable drawback in conventional pickling processes—is completely eliminated. In addition, it is claimed that the process lends itself to applications involving the pickling of tubes and wire and that it can easily be adapted to automatic pickling lines.

* * *

As reported briefly in *Product Engineering* (March 21, 1960), a new **tough and heat-resistant resin** developed in Japan is claimed to be superior in these respects to the acetal resins now nearing production in the U.S.A., as well as being equally resistant to friction. Although the new plastic, which should be especially suitable for wheels, gears, and machine parts, is, like the American material, made from formaldehyde, it is stated that the manufacturing process is entirely different, the Japanese technique involving dehydration of formalin, followed by mixing it with a special solvent, coolling to below −100°F, and exposure to gamma radiation (Co 60) for some seconds. Despite the apparent complexity of the process, it is claimed, however, that the Japanese resin can be produced more cheaply than the American material, and plans for its commercial production are now under way.

* * *

Differing basically in operating principles from conventional strain-gauges, a new Japanese **germanium strain-gauge** described in *Keisoku* (No. 12, 1959) makes use of the piezo-resistance and high anisotropy of germanium crystals. Experiments in connection with the reliability and operational range of the new strain-gauge have shown that it has particularly high sensitivity and temperature stability when made up of a pair of *n*-type crystals with nearly equal electrical resistances and with orientations of [110] and [100] respectively. It has also proved extremely suitable for measuring dynamic strain, giving a good response to vibrations of frequencies which are 100 times higher than those that can be measured with conventional strain-gauges.

* * *

A new control principle described in *Machine Design* for March 17, 1960, makes it possible to produce devices which are in many ways analogous with thermionic valves. Designated the **fluid triode**, the new device depends for its action

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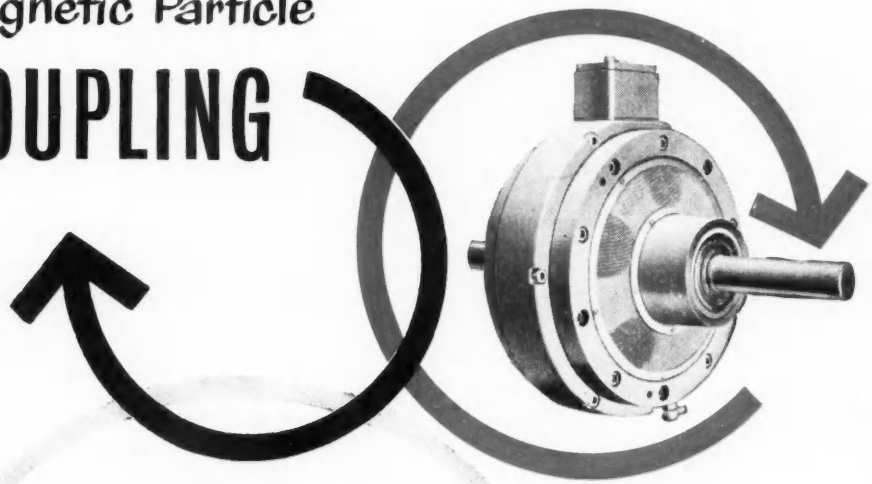

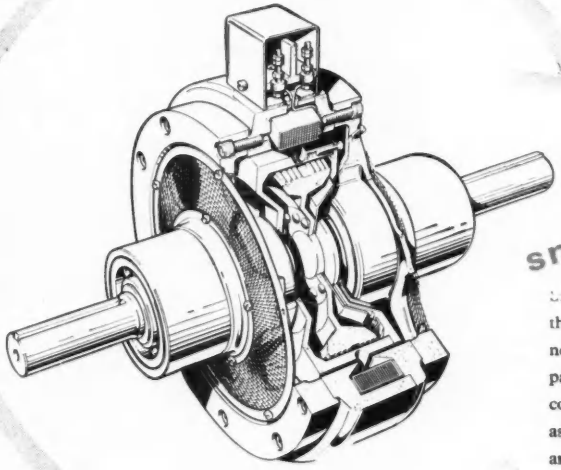

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The MINIDIGEST

on the collision between low-pressure-gas control jets and a high-pressure power jet and, like thermionic valves, the control jets of the fluid triode can accept both a bias and a superimposed alternating signal, so that they can be used in many applications in which thermionic valves or transistors are currently employed. Because the device has no moving parts, it can operate at white heat when constructed of refractory materials and can also handle signals in the audio-frequency band. In addition, it is rugged, simple, reliable, and requires no maintenance, while its cost in applications where fluid-triode systems can replace electronic devices is estimated to be 1% of that of a transistor or valve.

* * *

A paper in the Czechoslovak journal *Slévarenstvi* (No. 1, 1960). summarizes the results of recent laboratory tests in connection with the **vacuum-degassing of tin bronzes,** using a graphite crucible containing 30 kg of the molten metal and a vacuum of from 1 to 10 mm Hg for from 1 to 3·5 min. It is stated that, as a result of this vacuum-degassing treatment, the specific gravity of the tin bronzes used was increased by about 0·1 to 0·3, while their mechanical properties were greatly improved, their corrosion resistance at high temperatures was increased, and there was a marked reduction in porosity. It is pointed out, however, that even the smallest trace of residual phosphorus in the molten bath impairs the beneficial effects otherwise obtained by the vacuum-degassing treatment and leads to a sharp reduction in the mechanical properties of tin bronzes.

* * *

Diamonds are nowadays used on a large scale for use in lathe bits, drills, grinding machines, wire-drawing dies, etc., but, as pointed out in *Philips Technical Review* (No. 6, 1959/60), industrial diamonds have a maximum useful life only when given a definite specific orientation in the tool. For the purpose of **orienting diamonds properly in tools,** it is necessary to know the orientation of its space lattice, and this can be effected by the X-ray diffraction method which, though very accurate, is a time-consuming operation. It is now possible, however, to overcome this drawback of the X-ray diffraction method by means of the X-ray image intensifier, which permits direct visual observation of the Laue diagram, and reduces the work of orienting diamonds to only a few minutes. Furthermore, the process is inherently simple and can easily be mastered in a few hours.

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BUSINESS NOTES

Covering a total floor area of 8000 sq ft, and comprising facilities for flame-cutting plate up to 20 ft long, 6 ft wide, and 8 in. thick, a new fabrication shop has been added to the Sheffield works of **Keeton, Sons & Co. Ltd.**, a member of the **Firth Cleveland Group**. The completion of this shop enables the firm to construct all its future sheet metal working machinery to a new modern design in fabricated steel, in preference to cast iron.

* * *

It is announced by **Turner Brothers Asbestos Co. Ltd.** that their Glasgow office has now been moved to 80 York Street, Glasgow, C.2. The telephone number and Telex address remain unchanged, i.e., Central 2571 and Telex 77–113 respectively.

* * *

As a further step in the development of their industrial-engine business, the **Ford Motor Company Limited,** Dagenham, announce that a new sales operations group has been formed, and that the sales, supply, production, and advertising functions have been reorganized. The new operation is headed by Mr. G. T. Jones, manager of industrial-engines sales operations, with Mr. G. J. Carroll, manager of overseas sales, and Mr. W. R. H. Temple, manager of U.K. sales.

* * *

Cable & Wireless Ltd. have decided to build a new cable-laying ship which will be designed to lay and handle all known types of amplifiers and cables, including the kind to be used in the 28,000-mile Commonwealth round-the-world telephone cable. The ship will be launched in 1962, and full specifications will be completed in about three months. It has, however, already been decided that its gross tonnage will be about 7000 tons, and that its steaming range will be 8000 miles, its sea endurance 60 days, and its maximum speed 15 knots. Its carrying capacity will be 1200 miles of lightweight telephone cable with repeaters, or 1500 miles of conventional telegraph cable.

* * *

A licensing agreement has been concluded between the **Albert Mann Engineering Company Limited,** of Essex, with the **Loma Machine Mfg. Co. Inc.** and its subsidiary, **Lobeck Casting Processes Inc.,** of New York, U.S.A. The new agreement extends to the British Commonwealth, exclusive of Canada, and to the outer seven countries of the European Free Trade Association, and facilitates the supply of Loma and Lobeck metal-processing equipment on a basis of British construction. The Albert Mann Engineering Co. Ltd. have also taken over the whole of the share capital of **Roll Race Conveyors Limited,** and with it the right to manufacture and sell conveyors and handling equipment incorporating the patented roll-race system of rolling loads.

* * *

Silicon of the highest quality commercially available anywhere in the world is to be made in the U.K. by **Monsanto Chemicals Limited.** This development is the result of an agreement with the **Siemens Companies,** of West Germany, who are the originatoss of the manu-

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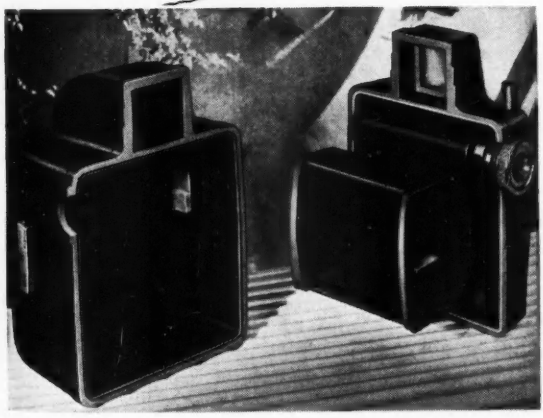

The rapid expansion of the photographic market has been accompanied by an ever increasing demand for a low-cost camera capable of taking photographs usually associated with more expensive models.
To meet this demand the Vista 12 was designed. It is another excellent example of how much can be produced for how little, when designer and plastic moulder work closely together.
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BUSINESS NOTES

facturing process which Monsanto is to operate at its factory in Ruabon, North Wales. Production will begin in the last quarter of 1960, and the Monsanto plant will produce float-zoned single crystals of high *p*-type resistivity or doped float-zoned single crystals of *p*-type or *n*-type resistivity. Monsanto will also supply polycrystalline rod for further processing, doping, and crystal-forming by customers.

* * *

An agreement has been concluded between the **English Electric Valve Company Co. Ltd.**, of Chelmsford, Essex, and **Eitel McCullough Incorporated**, U.S.A., for the exchange of technical information, etc., in connection with a large range of klystrons, travelling-wave tubes, and power tubes. As a result of this agreement, both companies will be able to enlarge the range of tubes in their respective catalogues and can get into production quickly on a composite range of each other's products in these fields.

* * *

It is announced that **Cooper & Co. (Birmingham) Limited** are to acquire a 50% interest in **Volcrepe Limited**, of Glossop, Derbyshire, who will concurrently increase their issued capital from £130,000 to £195,000. Cooper & Co. (Birmingham) Limited are well-known manufacturers of high-grade felts and felt fabrications, while Volcrepe Limited produce a wide range of rubber and synthetic products, including sponge-rubber and plastic foams. Both are private companies and are already associated as joint proprietors of **Cooper & Co. (Foams) Ltd.**

* * *

Winston Electronics, Ltd., of Shepperton, Middlesex, has become a wholly owned subsidiary of **The Dynamics Corporation of America**, of New York. The terms of the merger agreement include payment in cash, together with a large block of Dynamics Corporation stock, in return for the total shares, privately held, of Winston Electronics Ltd. Mr. F. Winston Reynolds will continue as chairman and managing director, Mr. R. Laurence as director of research and technical director, and Mr. J. Samuels as works director, under long-term contracts. Mr. T. Anderson leaves the board.

* * *

It is announced by the **Pioneer Oilsealing & Moulding Company Limited**, of Colne, Lancashire, that they have purchased Lower Clough Mill at Barrowford, Nelson, East Lancashire, and will enter into occupation later this year. The new premises provide 130,000 sq ft of floor-space.

* * *

The **Hanovia Lamps Division** of **Engelhard Industries Ltd.**, of Slough, Bucks., have taken over the sole agency in the U.K. for **Heraeus Quarzschmelze G.m.b.H.**, of Hanau, West Germany, who are well known as manufacturers of high-quality fused quartz in both optical and commercial grades for all industrial and laboratory applications.

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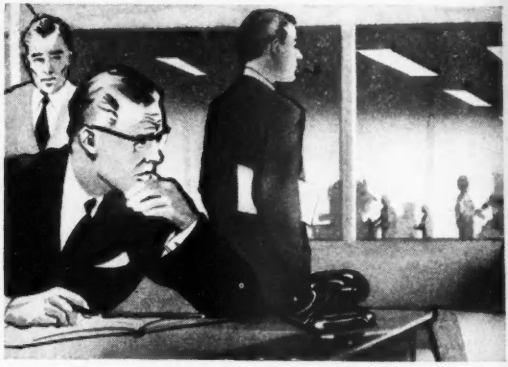

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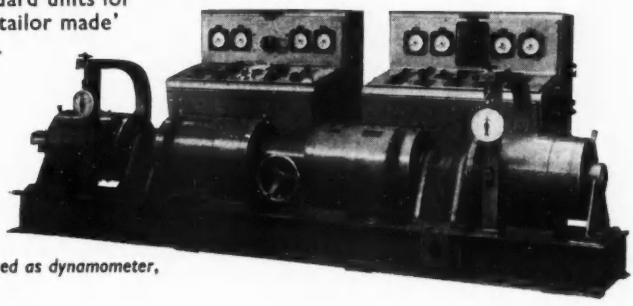

Recently supplied to the Welsh College of Advanced Technology, Cardiff — a multiple motor generator set, comprising 4 machines and two control desks. The machine unit comprises:—

- *7h.p. D.C. variable speed motor, arranged as dynamometer, complete with Tacho-generator*
- *4kVA alternator*
- *4kVA alternator with rotatable stator*
- *7h.p. synchronous motor (left to right) arranged as dynamometer*
- *The complete unit can be split into two motor-alternator sets*

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P2827

CONTRACTS

Following the successful installation of two large auto-transformers for the Saskatchewan Power Corporation of Canada, The General Electric Company Limited of England has been entrusted with a further order valued at $235,000 for another three transformers of similar design. These transformers have a voltage ratio of 138/72 kV, two of the units being rated at 22·5/30 MVA, and the other at 37·5/50 MVA. Designed to operate in temperatures down to — 40°C, the transformers are fitted with on-load tap-changing gear and are of the oil-immersed type. Cooling fans, mounted beneath the oil-cooling radiator banks, come into operation automatically whenever the higher of the two specified transformer outputs is required.

* * *

One of the largest orders ever to be negotiated in the Sudan, for a textile mill worth nearly £6,000,000, has been secured against world-wide competition by a British consortium comprising The English Electric Company Ltd., Platt Brothers (Sales) Ltd., and Marples Ridgway and Partners. The mill is being built in Khartoum for Mr. John Theodoracopulos, the President of the Sudan American Textile Industry John Theodoracopulos Co. Ltd. and is being financed from American and British sources. The mill, which will start operation in 1961 and will be in full production by 1962 with 3000 employees, is expected to have an output of 75,000,000 yards of cloth per year. The civil contractors are Marples Ridgway and Partners. The English Electric Company Ltd. will supply the diesel generating plant and all equipment for the distribution and use of the power, Platt Brothers will supply the spinning machinery, British Northrop the looms, and Sir James Farmer Norton the dyeing and finishing machinery.

* * *

Orders for electrical equipment worth nearly £2,250,000 have been placed with The General Electric Company Ltd., of Witton, Birmingham, by Richard Thomas & Baldwins Ltd., for their new Spencer Works at Llanwern, Monmouthshire. The contract embraces the main drives for the finishing train of the 68-in. hot-strip mill, which will be capable of rolling steel strip at 3250 fpm and will be one of the most powerful mills of its kind in the world. Five of the six stands will be driven by d.c. motors, each rated at 8000 hp, and the sixth by a 7000-hp motor. Grid-controlled mercury-arc rectifying plant, totalling in output 37·6 MW, will convert the 33-kV incoming supply to 1500 V d.c. for the main motors. G.E.C. is also supplying a considerable amount of ancillary plant for the hot-strip mill, including electric drives and equipment for the run-out tables and hot-strip coilers. The complete electrical equipment for two single-stand temper mills in the cold-rolling department will also be supplied by G.E.C.

In addition, it is announced that a further contract, valued at £2,000,000, for power-plant and electrical equipment has been placed with G E.C. by Colvilles Ltd., for extensions to the power-house at their Ravenscraig Iron and Steel Works, near Motherwell. Included in the contract are two turbo-generators, one of 20-MW, 30-

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CNLY

CONTRACTS

MVA, and the other of 12-MW, 28-MVA capacity; a turbo-blower, rated at 90,000 cfm, 40 psig; a 200,000-lb/hr gas-fired boiler; feed heaters, condensers, and ancillary plant; and all the motors, switchgear, transformers, and cabling for auxiliary services. Also being supplied are two 30-MVA 33/11-kV transformers and the necessary 33-kV and 11-kV switchgear.

* * *

P. G. Engineering Ltd., of Stockton-on-Tees, a member of the Power-Gas Group, announce that they have recently received contracts having a total value exceeding £1,250,000 for process plant to be installed in Canada and in India. The Canadian contract has been obtained from Brockville Chemicals Limited for the complete design, construction, and commissioning of a hydrogen plant at a new works now in course of erection near Maitland, Ontario. This plant will produce 15,000,000 cu ft of hydrogen per day, mainly for ammonia synthesis, using as a feedstock natural gas delivered by pipeline from Western Canada, and will consist of Texaco partial-oxidation units operating at about 400 psig, carbon monoxide in the Texaco gas being converted into hydrogen and carbon dioxide in a P.G. design of pressure-conversion plant using a P.G. catalyst. The carbon dioxide is then removed from the converted gas by the Bonfield hot potassium carbonate and monoethanolamine absorption processes.

The Indian contract has been received from Fertilisers & Chemicals, Travancore, Ltd., South India, for a Texaco partial-gasification plant to produce carbon monoxide and hydrogen, followed by high-pressure conversion of carbon monoxide, and the removal of carbon dioxide and residual sulphuretted hydrogen by water-scrubbing. The plant will initially process naphtha, but is laid out in such a way that, if fuel oil is to be used, the additional acid-gas purification plant can be added. An interesting feature of this plant is that the carbon produced in the Texaco generator is recovered and recycled.

* * *

A contract worth nearly £2,500,000 for hydro-electric generating plant for two new Spanish power-stations has been obtained by The English Electric Company Limited in the face of strong European competition. The equipment comprises three 108,000-hp pump-turbines and three 83,333-kVA alternators for installation at Valdecanas, and four 36,000-kVA alternators for installation at Torrejón, both these power-stations being about 120 miles south-west of Madrid. This equipment, together with the associated 230-kV and 138-kV airblast switchgear, has been ordered by Hidroeléctrica Española, the power-stations being the first to be built on the Spanish section of the River Tagus. The 108,000-hp pump-turbines at Valdecanas are the most powerful in the world.

In addition, The English Electric Company Limited has been awarded a major contract by the Indian Railway Board for the complete electrical equipment, including control gear and traction motors, for ten 3600-hp, 1500-V d.c. electric locomotives. These locomotives will be produced at the Chittaranjan Locomotive Works and will be the first electric locomotives to be built in India. The electrical equipment for these locomotives will be so designed that, should a failure occur in the control equipment, operation is ensured by cutting out half the control gear and operating with only the other half in circuit.

* * *

The largest rolling mill of its type in Western Europe has been ordered by James Booth Aluminium Ltd. as the first part of its £5,000,000 re-equipment and expansion programme, and is expected to be in operation in the company's Kitts Green Works, Birmingham, during 1961. The mechanical side of the new plant, costing approximately £1,500,000, has been ordered from the Loewy Engineering Co. Ltd., of Bournemouth, Hants., and is designed to roll aluminium and aluminium-alloy slab ingots weighing up to 6 tons, for the production of plate, sheet, and strip. Included in the plant is a reversing 4-high hot mill, 148-in. in width. As well as providing much larger sizes of aluminium-alloy plate, particularly to meet the growing demands of the shipbuilding, chemical, aircraft, and atomic-energy industries, the new plant will greatly augment the production capacity for all flat rolled products.

* * *

A major order, worth more than £400,000, has been received from the aluminium industry by the A.E.I. Heavy Plant Division for germanium rectifiers with an installed capacity of 42 MW for use in an extension to the smelter at Bell Bay, Tasmania. A similar order was received in December 1959 by the Division for the largest aluminium producer in Norway (Ardal og Sunndal Verk) for equipment with a capacity of 108 MW.

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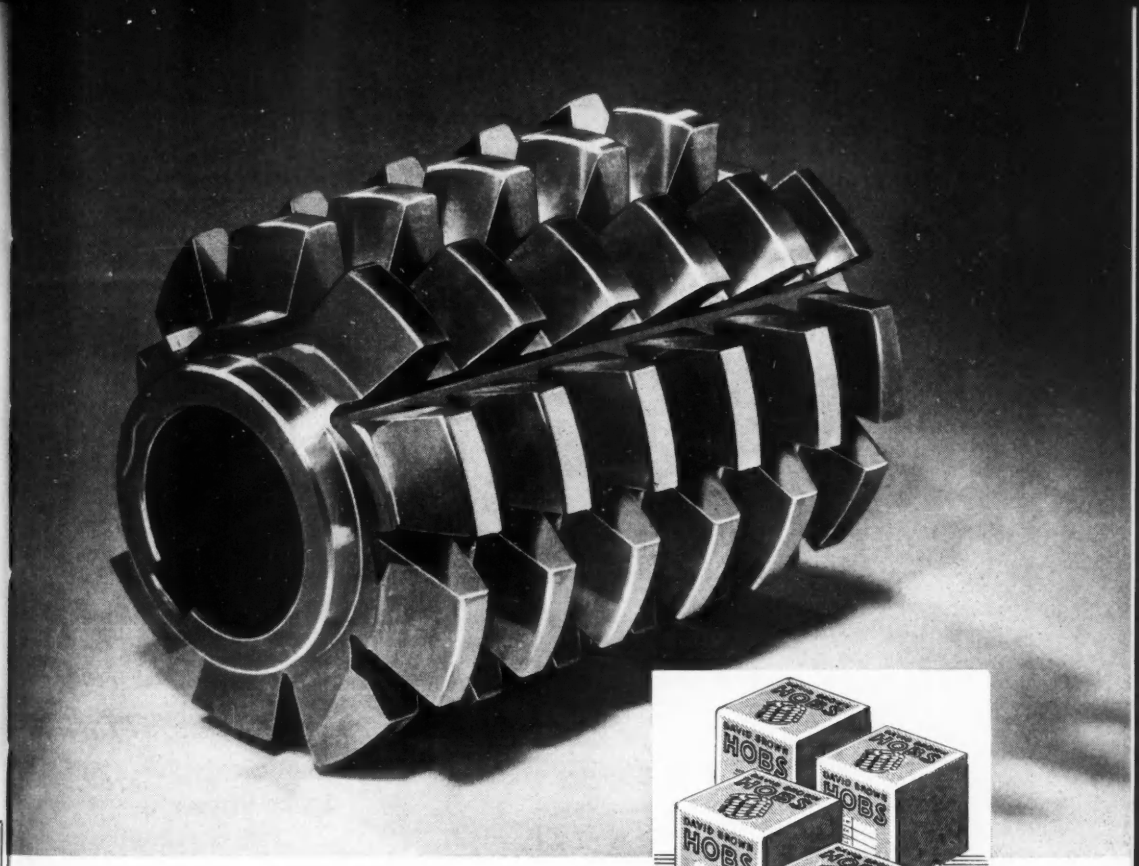

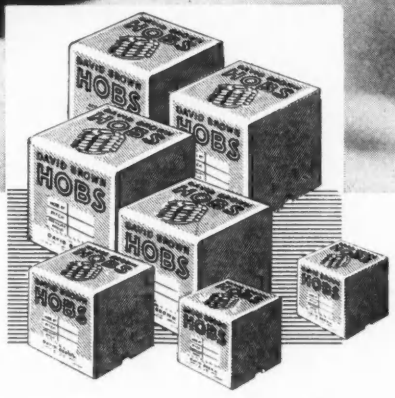

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PERSONAL

Mr. F. E. Wilson has been appointed managing director of B. Elliott (Machinery) Ltd., of London, N.W.10, and also joins the boards of the Victoria Machine Tool Co. Ltd. and of the Cardiff Lathe & Tool Works Ltd.

* * *

As a result of the offer by Albright & Wilson Limited for the capital of A. Boake, Roberts & Co. (Holding) Ltd. having become unconditional, **Mr. F. G. Pentecost,** chairman of the latter company, has been appointed a director of Albright & Wilson Limited.

* * *

Hagan Controls Limited, one of the Plessey Group of companies, announce that **Mr. K. R. Sandiford, B.Sc.(Eng.),** has joined the company as general manager.

* * *

Mr. B. Heath, D.F.C., M.A., managing director of Powell Duffryn Carbon Products Limited and a director of other companies in the Powell Duffryn Group, has resigned to take up another appointment. Following Mr. Heath's resignation, **Mr. R. Turner, M.I.Mech.E.,** acting managing director of Powell Duffryn Technical Services Limited, has joined the board of Powell Duffryn Carbon Products Limited as deputy chairman, while **Mr. F. W. Stokes,** a director and the present works manager of the company's factory at Hayes, has been appointed general manager.

* * *

Stone-Platt Industries Limited, of London, S.W.1, announce the appointment to their board of directors of **Sir Cuthbert B. Clegg.** In addition, **Mr. E. A. J. Hall, B.Sc., Ph.D., M.I.E.E.,** has been appointed technical director of Epsylon Industries Limited, a member of the Stone-Platt Industries Group.

* * *

Mr. N. Readman, managing director of The Consolidated Pneumatic Tool Co. Ltd., London, has been elected to the board of directors of the New York parent company, the Chicago Pneumatic Tool Company, New York.

* * *

Tne English Steel Corporation Limited announce that **Dr. C. J. Dadswell** relinquishes his office of managing director of Davis & Lloyd (1955) Limited, and is appointed chairman. **Mr. C. Muirhead, O.B.E.,** succeeds Dr. Dadswell as managing director. Dr. Dadswell is a director of the English Steel Corporation, and Mr. Muirhead a special director.

* * *

It is announced by Arusha Industries Limited that **Mr. A. B. Lidderdale, M.I.Mech.E., M.I.Prod.E.,** formerly a member of the Cables Group Board and deputy to the managing director of Telcon Limited, has been appointed personal assistant to the chairman of

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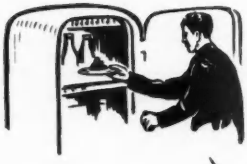

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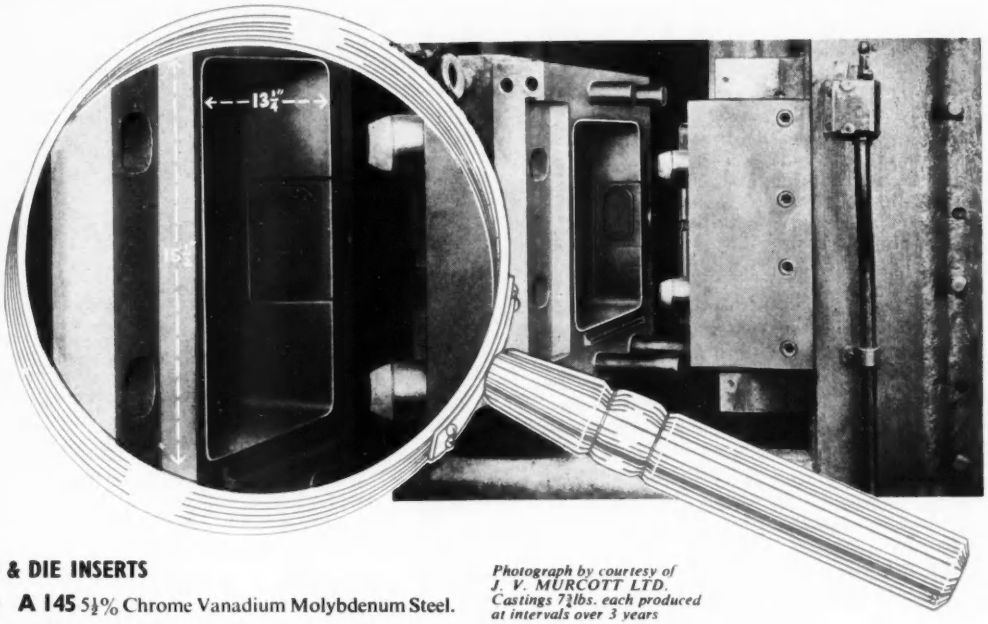

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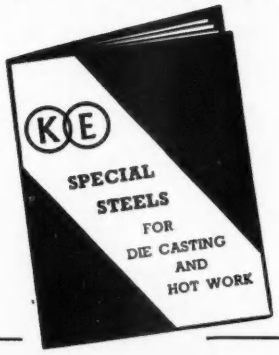

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PERSONAL

Arusha Industries Limited. **Mr. L. Ingham, A.M.I.E.E.,** formerly assistant general sales manager of Chloride Batteries Limited, has been appointed group sales manager of Arusha industries, while **Mr. A. J. Smith, B.Sc., A.M.I.Mech.E.,** formerly general works manager of the Glacier Metal Company, becomes the Group industrial engineer.

* * *

Following increasing expansion and industrial commitments, Foster, Yates and Thom Ltd., heavy precision engineers and boilermakers, of Blackburn, Lancs., have created the new post of assistant general manager. **Mr. O. D. Gwilliam** has been appointed to this position and will be assistant to **Mr. R. Lucas,** the company's general manager.

* * *

Following his resignation as technical assistant to the managing director of the Shell Chemical Co., **Dr. C. Webber** has been appointed a director of the Yarsley Research Laboratories and also of the Yarsley Testing Laboratories.

* * *

Richard Sutcliffe Limited, of Horbury, Wakefield, Yorks., announce the appointment of **Mr. M. Reid Moore** as general sales manager.

* * *

Mr. T. P. Everett, B.A., M.I.Mech.E., has joined the board of Hawker Siddeley Brush Turbines Ltd. as sales director.

* * *

It is announced by Electrothermal Engineering Ltd., of London, E.7, that **Mr. G. Wright, A.M.I.E.E., A.M.I.Mech.E.,** has joined the company as chief engineer.

* * *

Mr. A. Garratt has been appointed public-relations manager of D. Napier & Son Limited in succession to **Mr. C. G. Hollowell,** who has become the joint deputy publicity manager (general) of the English Electric Company Limited.

* * *

Mr. J. E. Smith, managing director of the National Gas & Oil Engine Co. Ltd., has been elected to the board of Mirrlees, Bickerton & Day Ltd., both of these companies being members of the Hawker Siddeley Group.

* * *

MR. OSCAR RENDELL

It is with regret that we announce the death on March 5, 1960, at the age of 75, of Mr. Oscar Rendell, M.I.Mech.E., a director of H. W. Kearns & Co. Ltd., after more than 51 years service with the company.

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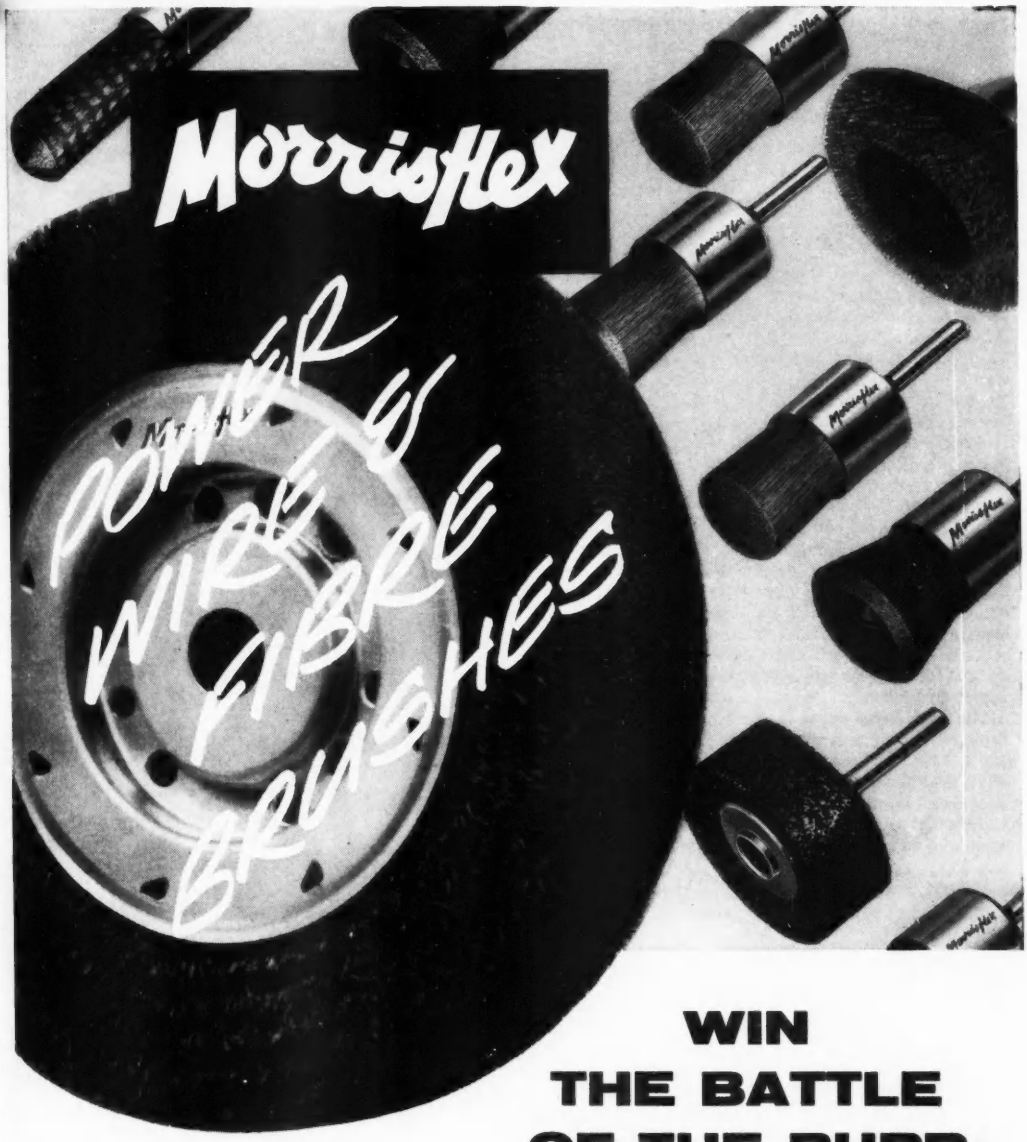

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NEWS ROUND-UP

Symposium on Wide-Strip Production

With new mills being built in Scotland and South Wales, wide steel-strip production is a subject that is now being studied very closely by the U.K. iron and steel industry. It is appropriate, therefore, that The Iron and Steel Institute should devote the technical sessions at its Annual General Meeting this year to a symposium on wide-strip production, the scope of this symposium being extensive, covering all aspects of strip production from steelmaking to manufactured goods.

The opening session will review the future requirements of the tinplate and vehicle industries, the major users of wide strip, and this will be followed by a session devoted to steelmaking practice, with papers from the Steel Company of Wales, the National Steel Corporation (U.S.A.), Cornigliano (Italy), and Hoogovens (Holland). The subjects under discussion include converter processes, oxygen in the open-hearth, and quality control. Strip rolling is dealt with in the third session, with papers from Davy-United and the United States Steel Corporation. The fourth session includes papers on the metallurgical principles of tinplate manufacture (S.C.O.W.), the rolling of very thin tinplate (United Engineering and Foundry Corporation, U.S.A.), high-speed rolling (John Summers), and annealing (Lysaghts, Australia, and S.C.O.W.). The final session deals with coatings, i.e., tin (S.C.O.W.), galvanizing (John Summers), and plastics (B.I.S.R.A.).

The symposium starts at the Royal Commonwealth Society, Northumberland Avenue, London, W.C.1, on May 3, 1960. The subsequent sessions, on May 4 and 5, will be held in the Hoare Memorial Hall, Church House, Great Smith Street, London, S.W.1. Further information can be obtained from the Secretary, The Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W.1.

Automatic Programme-Controlled Forging of Steel

For what is believed to be the first time in any country, the completely automatic programme-controlled forging of steel has recently been successfully demonstrated in the experimental forge of the British Iron and Steel Research Association in Sheffield. Forging was carried out by a precision-controlled 200-ton press interlocked with a fast, remote-controlled, experimental manipulator capable of longitudinal, rotational, and lifting movements, using electrical controls developed for both the press and manipulator to ensure fast, accurate operation and to synchronize the movements of the two machines.

During forging operations, the press and manipulator were controlled by a programme-control unit on which every detail of the schedule of forging operations had been set up. In this schedule, the upper and lower limits of the squeeze for every pass were given, the manipulator feed between strokes was selected, and the manipulation necessary between passes was also stored, the control unit signalling instructions to the press and manipulator in the appropriate sequence. The resulting finished forging in some respects exceeded the best current industrial standards as regards dimensional precision, and, even so, the job was accomplished twice as rapidly as could be expected from the most highly skilled forg-

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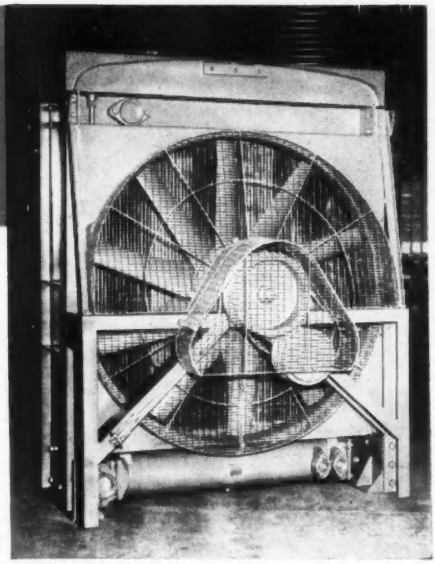

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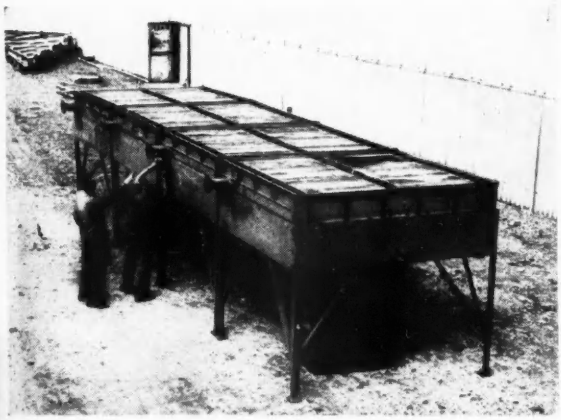

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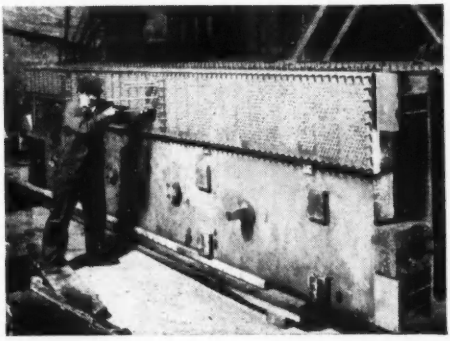

Evaporator for refinery by Procon (Great Britain) Ltd. being tubed with SERCKALBRA Photo by courtesy of Richardson, Westgarth & Co. Ltd.

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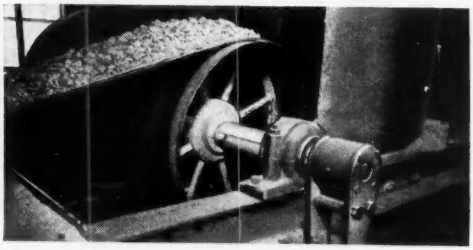

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ing crew. Despite this fact, it is stated that even more rapid operation will shortly be practicable. The forging schedule was calculated in advance from a theory, worked out in the laboratory, of the change in shape during forging.

The Fourth Production Exhibition

The Fourth Production Exhibition, to be held in the National Hall, Olympia, London, from April 25 to 30, 1960, has a special appeal to management and, in particular, to all those in industry whose task it is to plan for productivity, providing, as it does, an effective cross-fertilization of important ideas in every industry.

The exhibition is selective, all exhibits being related to the topic of producing goods more cheaply and efficiently. The 1960 exhibition promises to contain features of more than usual value, and one prominent display will consist of the use of computers in production control, while an impressive exhibit will be staged by one of the leading motor-car manufacturers, who will show how the best principles of achieving quality, allied to productivity, have been applied to their own production. Another interesting feature will comprise exhibits from many small firms who, in numbers, form a high percentage of the total engaged in engineering in Britain.

Apart from exhibits by development associations, such as the British Electrical Development Association and the Tin Research Institute, there will also be exhibits from the British Productivity Council, the Central Electricity Generating Board, the British Association for Commercial and Industrial Education, and the British Standards Institution. In addition, a number of Technical Colleges will illustrate modern methods of training in production technology and allied subjects.

The Determination of Gases in Metals

It has long been recognized that minute traces of the gases oxygen, hydrogen, and nitrogen in a metal can significantly affect its mechanical properties and its service performance. In order to control these gaseous impurities, they must be measured accurately, and many new determination techniques have been evolved in recent years. A forthcoming symposium on the determination of gases in metals, organized by the Society for Analytical Chemistry in conjunction with The Iron and Steel Institute and The Institute of Metals, will review the present position, and will survey the latest techniques available. In addition to authoritative review papers covering each of the three gases, there will be papers on vacuum-fusion, carrier-gas, activation-analysis, emission-spectrometric, and internal-friction methods of determination from experts in these fields.

The symposium will be held at Church House, Great Smith Street, London, S.W.1, on May 3 and 4, 1960. Further details and forms of registration can be obtained from the Secretary, The Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W.1.

Classified Advertisements

SITUATIONS VACANT

Applications are invited for the position of

STEEL WORKS PROJECT ENGINEER

from men qualified in the layout and operation of Steel Works Plant and the co-ordination of requirements for Heavy Shears, Handling Equipment and Ancillary Gear, etc.

Applicants should be able to guide general designs to meet specifications and supervise the manufacture of building of complete equipments.

The opening offers excellent prospects for a man of proved ability.

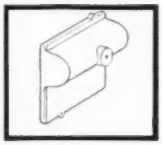
Please write, giving full particulars of age, training and experience, to Box ED14.

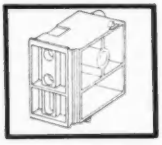
WANTED

Ball and Roller Bearings etc. wanted. Also surplus goods—especially hand tools—of all descriptions. R. Pordes, 138 New Cavendish Street, London, W.1. MUSeum 5250.

Visit Stand S 850 I.E.A. Exhibition May 23rd-28th

DMC* electrically...





60 amp. Input Junction Box moulded by A.E.I. Plastics (Aldridge) Ltd. for Siemens Edison Swan. The four moulded components are shown in the inset drawings.

Beetle Polyester D.M.C., the new fast-curing moulding compound, is especially suitable for moulding electrical components. It has excellent anti-track and electrical insulation properties, high mechanical strength; dimensional stability above normal for thermosetting materials; good heat resistance. A.E.I. Plastics (Aldridge) Ltd. use Beetle D.M.C. for moulding several types of electrical distribution gear, using conventional compression and transfer presses. Write for technical leaflets.

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B·I·P

NEW TECHNICAL BOOKS

Kempe's Engineers Year-Book for 1960. 65th edition. Edited by C. E. Prockter, M.I.E.E., M.I.Mech.E., under the direction of B. W. Pendred, M.I.Mech.E., M.I.S.I. 2750 pages. Publishers: Morgan Brothers (Publishers) Ltd., 28 Essex Street, Strand, London, W.C.2. Price (two volumes in case): 87/6; postage 2/6.

As always, this valuable reference work provides a ready source of information on practically every branch of engineering and, as in previous editions, every chapter in this new edition has received close attention, ensuring that the contents are kept up to date. Thus, chapters which have been rewritten include those on " Electronic Engineering ", " Nuclear Power " (replacing the chapter on " Atomic Power "), " Prestressed Concrete ", " Diesel Locomotives and Railcars ", " Railway Brakes ", " Railway Signalling ", and " Naval Architecture ". Moreover, useful additions have been made to nine other chapters, and alterations resulting from the issue of new and revised British Standards have been included.

Data Sheets on Moulding Sands. 2nd edition, 1960. 56 pp., 60 illustrations. Published by The British Steel Castings Research Association, 5 East Bank Road, Sheffield 2. Price: 30/–.

As a result of the favourable reception accorded to this book and numerous requests for further information on moulding sands since the appearance of the first edition in 1956 and a second impression in 1957, both restricted to members of The British Steel Castings Research Association, it was decided to make it available to a wider readership. The result is this second edition, which has been revised and enlarged, and which will certainly be of considerable value to those concerned with the production, distribution, and use of moulding sands, and also to research workers, technical colleges, reference libraries, and information bureaux.

The data sheets included in this book are the result of the first systematic attempt so far made in Great Britain to present clearly and conveniently a large amount of information on the subject. The sources and properties of no less than 45 sands, both British and Continental, suitable for moulding purposes in steel-foundry work, are presented on each data sheet, the necessary information having been presented by the Association, members of B.S.C.R.A., sand suppliers, and the Refractories Department of Sheffield University. The type, source, and supplier of each sand is clearly stated, and the chemical and mechanical analyses are set out in tabular form. The grain shape and refractoriness are indicated, and a graph, showing the cumulative grading curves, is reproduced in each case. In addition, graphs showing the bonding properties appear on a number of these data sheets. Furthermore, a concise survey of the types and occurrence of sands in Britain is included, as well as explanatory notes relating to the data sheets.

Principles of Servomechanisms. By A. Tyers, A.M.Brit. I.R.E., and R. B. Miles, Grad.Brit.I.R.E. 184 pp., 190 illustrations. Publishers: Sir Isaac Pitman & Sons, Ltd., Parker Street, Kingsway, London, W.C.2. Price: 25/–.

Although the use of servomechanisms is becoming more and more frequent, would-be students of the subject are often debarred from further progress through lack of a knowledge of advanced mathematics, as the study of servomechanisms normally involves the formation and solution of various types of differential equations. This book is therefore directed towards those who do not require a rigorous treatise on servomechanism theory but who would welcome a practical knowledge of these mechanisms without needing the background mathematics essential for advanced studies.

With this object in view, this interesting book admirably serves its purpose, even though it has made it necessary to generalize on the effects of some types of feedback and control methods—an inevitable compromise if the use of calculus must be avoided. In fact, no mathematical knowledge beyond elementary trigonometry is required of the reader, though it is assumed that he is familiar with general radio and electronic circuitry and the fundamentals of electricity. In short, junior engineers and technicians should find the practical details given in this book a very helpful introduction to machines incorporating automatic control.

Applied Heat for Engineers. 3rd edition, 1959. By J-B. O. Sneeden, B.Sc., Ph.D., F.R.S.E. 394 pp., 170 illustrations. Publishers: Blackie & Son Limited, 17 Stanhope Street, Glasgow, C.4. Price: 25/-.

Providing comprehensive information for students of heat engines, this excellent book gives a clear and thorough account of the physical principles of heat and their applications to heat engines. As such, it has enjoyed a deserved popularity since the appearance of the first edition in 1947, and the publication of the second edition in 1953, which was enlarged to cover compressors and gas turbines.

In this third edition, there is an additional chapter on refrigeration, which should appeal especially to students of marine engineering and sea-going engineers taking the Ministry of Transport Examinations in Heat Engines. As before, a number of worked examples has been added in the text, and questions and their answers are included at the end of each chapter.

F.B.I. Register of British Manufacturers, 1960. 32nd edition, 1164 pages. Published for the Federation of British Industries by Kelly's Directories Ltd. and Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1. Price: 42/–.

As always, the F.B.I. Register is a comprehensive and accurate guide to a substantial cross-section of British industry, containing lists of the products and services of more than 7500 member firms under more than 5400 alphabetical headings.

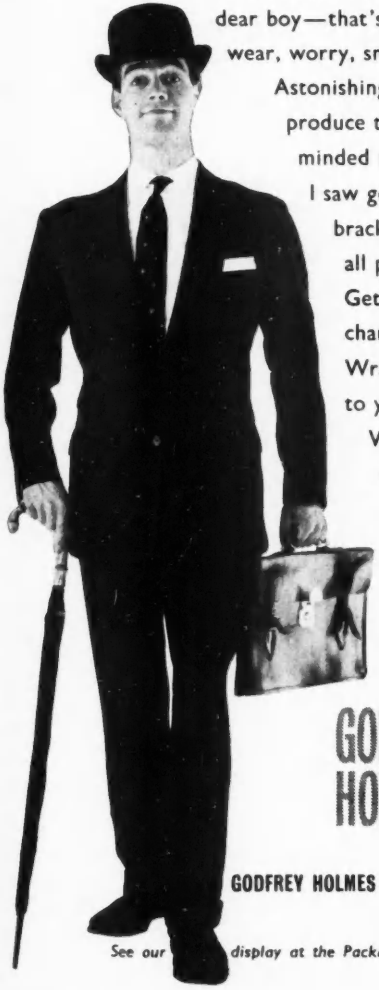
In addition to the classified buyers' guide, there are seven other sections in the Register, giving the addresses of companies and firms, and valuable information in connection with trade associations, proprietary names, trademarks, etc. In addition, French, German, and Spanish glossaries give translations of every product and term used in the main buyers' guide. There can be no doubt that, like its predecessors, this new edition will prove extremely useful to importers, buyers, trade commissioners, Chambers of Commerce, commercial attachés, reference libraries, and departments of trade and industry throughout the world.

The Lead Storage Battery. 4th edition, 1959. By H. G. Brown, A.M.I.E.E. 166 pp., 81 illustrations. Publishers: John Sherratt & Son, Park Road, Altrincham, Cheshire. Price: 24/–.

Beautifully produced and illustrated, this well-written and authoritative book constitutes a *vade-mecum* of the lead storage battery and is an invaluable reference work and guide to all those who employ and maintain lead-acid cells of every description.

After a brief introduction dealing with the chemistry of the lead-acid cell, details are given of the formation and structure of plates and of Planté and Faure types of cells. In addition, information is given on stationary batteries, battery traction, stand-by batteries, batteries for special duties, and battery economics, as well as the electrical characteristics of batteries. The question of impurities which may seriously affect both the performance and life of batteries is also discussed, and a brief exposition of the ionic theory is included. An unusually comprehensive index is appended.

who said plastic mouldings?



No—not common or garden plastic mouldings but the real stuff. Nylon, dear boy—that's the answer to precision, wear, worry, smooth and silent running. Astonishing what these Wragby people produce these days. Makes a metal-minded man meditate.

I saw gears, pulleys, bushes, bearings, brackets, gliders, washers and clips all produced in nylon.

Get your mind off nylons for a change — ring those people at Wragby — tell them to talk *nylon* to you. Apart from nylon these Wragby people cover the whole field of thermo-plastics and it costs nothing to talk. They actually offer the full facilities of their design and development staff — and that's really something these days.

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NYLON FOR ENGINEERS
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LATEST INDUSTRIAL LITERATURE

1. Link Belts. A comprehensive 32-page brochure deals with a wide variety of leather and synthetic-rubber link belts which combine flexibility and durability with silent and smooth running and low power absorption. Numerous applications of link belting are described, and tables of power-correction factors and other useful design data are also given. A number of supplementary leaflets dealing with extruded rubber sections, fenders, and tools for belt installation are also available on request.

2. Milling Cutters. The range of heavy-duty high-speed-steel milling cutters presented in a 4-page leaflet includes helical cut-end mills, slow-spiral and taper-shank end mills, reflex and woodruff cutters, as well as slotting drills and copy and die milling cutters. These cutters, which are claimed to have exceptionally long life, can be used to best advantage at heavy tooth loads without the necessity of frequent regrinding.

3. Pneumatic Equipment. Particulars are contained in an illustrated 8-page brochure of a range of pneumatic equipment, including single- and double-acting air cylinders, hydro-pneumatic units, pressure switches, and boosters, as well as pilot electro-valve units. Practical examples of applications of this equipment in welding guns, and in cutting-off and drilling machines are also dealt with.

4. Oil-Retaining Bearings. A well-presented 12-page catalogue details the fundamental operating principles and performance data of a range of sintered oil-retaining bearings. Manufactured by powder metallurgy, these bearings possess a strong and rigid structure and have exceptional oil-retention capacity. The range of applications of the bearings, which are produced in plain cylindrical, flanged, spherical, and closed-end versions, includes tractors, elevators, motor vehicles and trucks, pumps, compressors, line shafting, pulleys, clutches, and numerous types of machine tools.

5. Alloys for Jigs and Fixtures. Enabling an increase in the effective life of jigs and fixtures and maintaining the original accuracy of the shape over long periods, a corrosion- and abrasion-resistant hard-facing alloy is presented in an illustrated 12-page brochure. The applications listed include drilling and milling jigs, cams, chain-link blocks, slide wedges, interlock levers, etc. Recommendations are also given on the design of hard-wearing ejectors, grip joints, tipped plates, and cam plates.

6. Silicone Fluids. An illustrated 8-page brochure describes the engineering applications of the range of silicone fluids produced by a leading manufacturer. The silicone fluids have good thermal stability, show a remarkably small reduction in viscosity with increasing temperature, and resist breakdown due to shear. They are water-repellent and retain good dielectric characteristics over a wide range of temperatures and frequencies. Other desirable properties of the fluids are low volatility, low freezing point, and high flash point.

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Please send free and without obligation the literature indicated by the following circled numbers:

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Name .....

Position .....

Company.....

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7. Self-Locking Screws, Nuts, and Bolts. Eliminating the need for lock washers, safety wiring, or any other costly locking devices, a range of self-locking screws, nuts, and bolts is presented in a 6-page brochure. The locking element of these units consists of a tough resilient nylon pellet which is inserted into the body of the nut, screw, or bolt, setting up a spring-like wedging action and securely gripping the thread. The application of these fixing elements saves blind-hole tapping and other complex operations, as a self-locked bolt can be used through a tapped hole without the risk of fluid leakage.

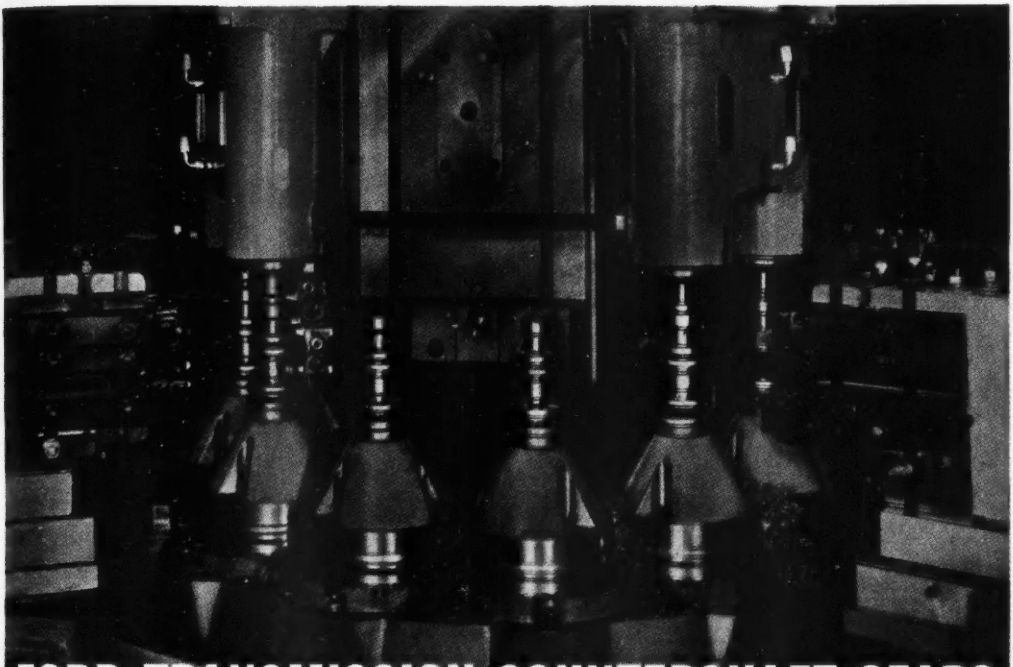
8. Ball Screws and Ball Spindles. Translating efficiently rotary motion into linear motion with a minimum of effort and freedom from backlash, a range of ball screws and ball spindles described in an illustrated 6-page folder includes high-helix, trunnion, multiple-circuit, and preloaded ball screws and ball splines with operating-torque ratings from 35 to 50,000 lb in. Guidance is given on the selection of suitable components for torque-thrust conversion, and tables of operating loads, life-conversion factors, and critical speed ranges are also included.

9. Air Compressors. A range of air compressors described in a 16-page brochure incorporates a number of advanced design features, such as a force-feed lubrication system, separate piston and gear pumps to the cylinders and running gears respectively, truncated aluminium pistons, and a single-piece box-type crosshead which requires no adjustment. The V-cylinder arrangement of the compressors and the use of flange-mounted motors help to minimise space requirements, drive being provided by squirrel-cage or slip-ring induction motors, or alternatively by a synchronous motor where power-factor correction is desired.

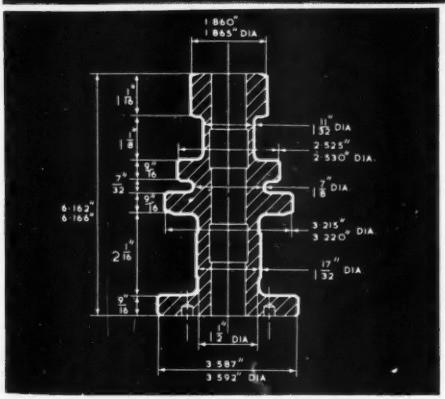
10. Permanent-Magnet Chucks. Providing greater gripping power, a powerful side grip for precision squaring, and rapid coupling and single-point control for gang chucking, the range of permanent-magnet chucks presented in a 20-page brochure includes rectangular and universal permanent-magnet chucks, as well as sine-angle chucks, for use on milling, jig-boring machines, etc. Details are also given of a tilting-block adapter which can be set at any desired angle to permit rapid setting of angular workpieces with practically no reduction in gripping power.

11. Magnetic-Amplifier Variable-Speed Drives. Wide speed range, instant starting, local or remote finger-tip control, and minimum maintenance are some of the basic advantages of the magnetic-amplifier variable-speed drives described in an illustrated 8-page brochure. The drives, which are recommended for applications in machine tools, conveyors, pumps, test rigs, extruders, vibrators, stokers, and pulverizers, comprise two units, namely, a magnetic-amplifier controller and a variable-speed d.c. motor. Against constant torque a stepless speed range of at least 20 : 1 is provided, and against constant horse power a 3 : 1 speed range, but wider speed ranges can also be obtained for special drives.

12. Flame Plating. An illustrated 6-page leaflet deals with a flame plating process, in which thin coatings of tungsten carbide are applied to various materials, thus achieving outstanding wear resistance under severe conditions of fretting corrosion, wear, and abrasion. The process involves the use of a specially constructed gun, in which particles of tungsten carbide are suspended in a mixture of oxygen and acetylene. When this mixture is ignited, a detonation takes place which heats the particles to a plastic state and hurls them from the barrel at a supersonic velocity, so that they embed themselves in the surface of the workpiece. A microscopic welding takes place, resulting in a tenacious bond. One of the major advantages of the process is that the temperature of the workpiece seldom exceeds 400°F. There is, therefore, little chance that the part being plated will warp, or that its properties will undergo any change.



FORD TRANSMISSION COUNTERSHAFT GEARS



MACHINED IN 45 SECONDS

This 12-spindle No. 10 Ryder Verticalauto produces two machined transmission countershaft gears at each index.

Stellite and H.S.S. Tools cutting at moderate speeds and feeds have eliminated swarf problems and hydraulic operation of the mandrels and automatic hydraulic operation of the Loose Headstocks make loading easy to achieve within the cycle time.

Ryder **VERTICALAUTO**

Thos. Ryder & Son, Limited, Turner Bridge Works, Bolton, England.
Makers also of single spindle Rydermatics and Piston Ring Lathes.

When FULLY AUTOMATIC WELDING is out of the question

...its a job for

ROCKWELD

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SEMI-AUTOMATIC PROCESS

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CO_2 SHIELDING

- ★ Excellent Penetration — high rate of deposition up to 27″ per minute
- ★ Weld deposit low in nitrogen, hydrogen and oxygen
- ★ Excellent shape and metallurgical quality of weld
- ★ Permits current densities 3-4 times those of normal hand welding
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Full technical data on request from

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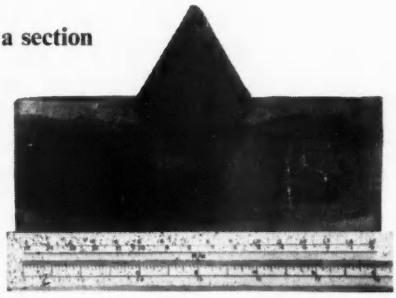
ELECTRO-SLAG WELDING—NEW APPLICATIONS

THINKING AT THE DESIGN STAGE

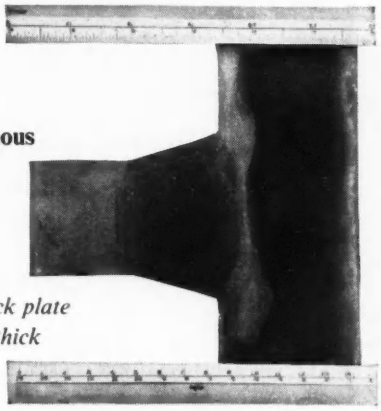
A new process frequently offers unique opportunities for improvement in quality, for lowering of production costs or even scope for truly original application. Re-assessment of problems in design may be possible. To promote new thinking at the design stage two new applications for electro-slag welding by the Rockweld-Vus Vertomatic machine are described.

Adding a section



(Above) One of many shapes of section which can be added to a plate or existing section

A homogeneous T-weld



(At right) Two-inch thick plate Teed to 2⅜" thick plate

This particular section was obtained with a single water cooled shoe on a flat surface. It could equally well be applied to a cylindrical surface. The shape is only typical of many which could be adopted and quite a wide range of low alloy steels can be imposed on dissimilar steel plates or forgings. The considerable depth of penetration in this example will be noted but penetration can be varied to suit particular requirements.

ADVANTAGES OF THE ELECTRO-SLAG PROCESS

Vertical Welds in heavy material, impossible by conventional methods.
Unlimited thickness can be welded.
Manipulation of work into position suitable for conventional welding, difficult and expensive with unwieldy heavy sections, is avoided.
Elaborate plate preparation is eliminated.
All welding is done in a single pass—the deslagging and chipping unavoidable with multi-pass welding is eliminated.
Comparative little flux powder is needed and there is no need for continuous flux recovery.
High thermal efficiency allows outstanding economy in welding power consumption.
Can replace heavy forging and casting of heavy parts.
Plate need not be accurately aligned.
The process is fully automatic.
Very high rate of deposition—up to 40 to 50 lb. per hour.

★ ***Production time can be rated in hours instead of days, with less welding labour.***

T-welds in heavy plates or forgings often present problems in design and construction. Homogeneity and shaping of such welds may be difficult in execution by conventional welding methods. Electro-slag welding overcomes such difficulties, provides 100% radiographic results and mechanical properties superior to plate material for most constructional steels. No plate preparation is necessary for this weld.

WELDING DATA

Welding data provided on this experimental section is not necessarily the optimum which could be derived from further tests:

Welding current	600/650 amps.
Welding voltage	36/38 V
Vertical speed of welding...	48" per minute
Wire consumed	0.5 lb. per inch of weld
Plate thickness	2¼"

WELDING DATA

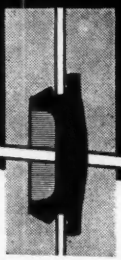
This weld was carried out with a single wire of ⅛" diameter. A fixed water cooled shoe was placed on one side of the preparation and a special movable shoe on the other side, using a standard Vertomatic machine.

Welding current	525/550 amps.
Welding voltage	45/46 V
Vertical speed of welding...	31.5" per hour

A new Grommet development

THE DOUBLE SEALING EMPIRE RUBBER GROMMET

infinitely accommodating in use: considerably reduces range of sizes because the same grommet can be used with several plate thicknesses or cable sizes



PAT. APP. No. 5255/59

This newly developed self-conforming grommet, because it is immediately self-locking against the elements, is the solution to many of an engineer's sealing problems.
Any one size will not only accommodate itself to a variety of mounting plate thicknesses, but (designed for cable or control rod) will take these in a variety of sizes and be weather-, water- and dust-proof at a variety of angles to the cable or rod.

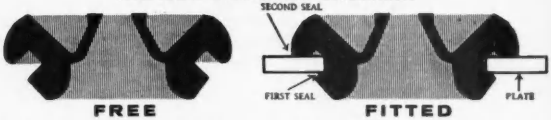
Because of its capacity to conform to many varying requirements, it enables a workshop stock range of grommets to be reduced to perhaps one tenth of that at present maintained.

THE NEW BLIND GROMMET

FREE

Note how when sprung into position the grommet provides a perfect double seal by its own permanent pressures. The angled groove also creates a tight pressure hold on the metal plate.

THE NEW DESIGNED GROMMET



FREE FITTED

In the cable grommet variety the same double pressure seal is created, allied to tight seal on various diameters of cable. This new grommet gives sound sealing at *all* vital points.

A useful feature of this cable grommet is that by reason of the designed taper of the cable entry and the flexibility of the web, a considerable angle of cable entry and a variety of cable size are possible. This avoids necessity for special grommets with angled bores.

In the conventional grommet, only one thickness of plate and only one size of cable can be accommodated. No effective seal is afforded by the parallel groove.

Now being produced in a range of sizes.

THESE GROMMETS WILL SOLVE YOUR SEALING PROBLEMS.

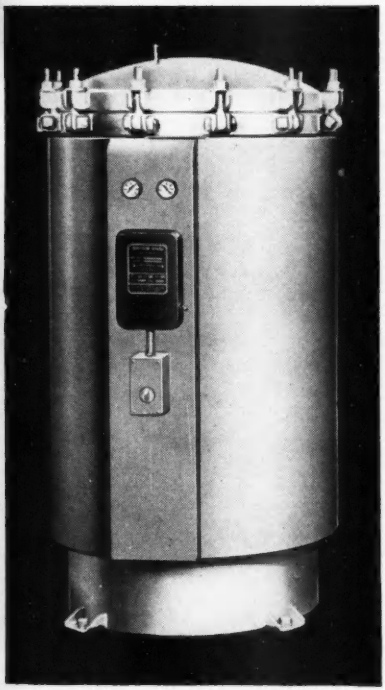
ENQUIRE
for catalogue section and detailed particulars.

EMPIRE RUBBER COMPANY · DUNSTABLE · BEDFORDSHIRE · ENGLAN

INTRODUCING THE

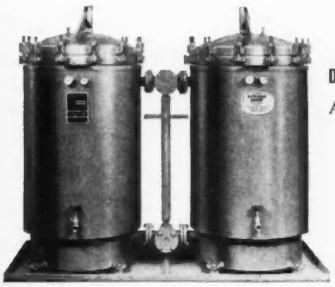
BIRFIELD HILCO range of

OIL FILTRATION EQUIPMENT



'R' SERIES FILTERS

For the continuous filtration of lubricating and fuel oils used in internal combustion engines, various types of industrial oils, coolants, fuel oils, solvents etc. used in manufacturing industries. Where floor area is limited the cartridges can be mounted in a number of cases piped in parallel. These are supplied with or without motor pump sets according to requirements.



DUPLEX FILTERS

All filters can be supplied in duplex units where it is essential that continuous filtration is required.

000 SERIES FILTERS

For fuel oil filtration, can be supplied either in duplex or simplex units.

'C' SERIES FILTERS

For high flow rate filtration of internal combustion engine lubricating oils using by-pass shunt or full-flow systems. Also for filtration of various types of fuel oils, industrial oils, coolants, solvents etc. used in manufacture and the chemical processing industries. These filters can be supplied with or without heaters.

Here is a new range of oil maintenance equipment specially designed for high efficiency operation at lower cost. Birfield Hilco filters will maintain new oil characteristics of any quality industrial and lubricating oils. As there is such a wide range of oils, and the conditions under which they are used require different methods for removing contamination, we have developed six filter medias to cope with these varying conditions.

for **high** efficiency at **low** cost...

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— assembled to customers drilling requirements

Herbert All-electric Drilling Machines are made in nine types for drilling holes from the very smallest, at 18,000 r.p.m., up to 1¼" diameter.

This equipment meets all general-purpose requirements. Unit construction and interchangeability enable special requirements to be easily met.

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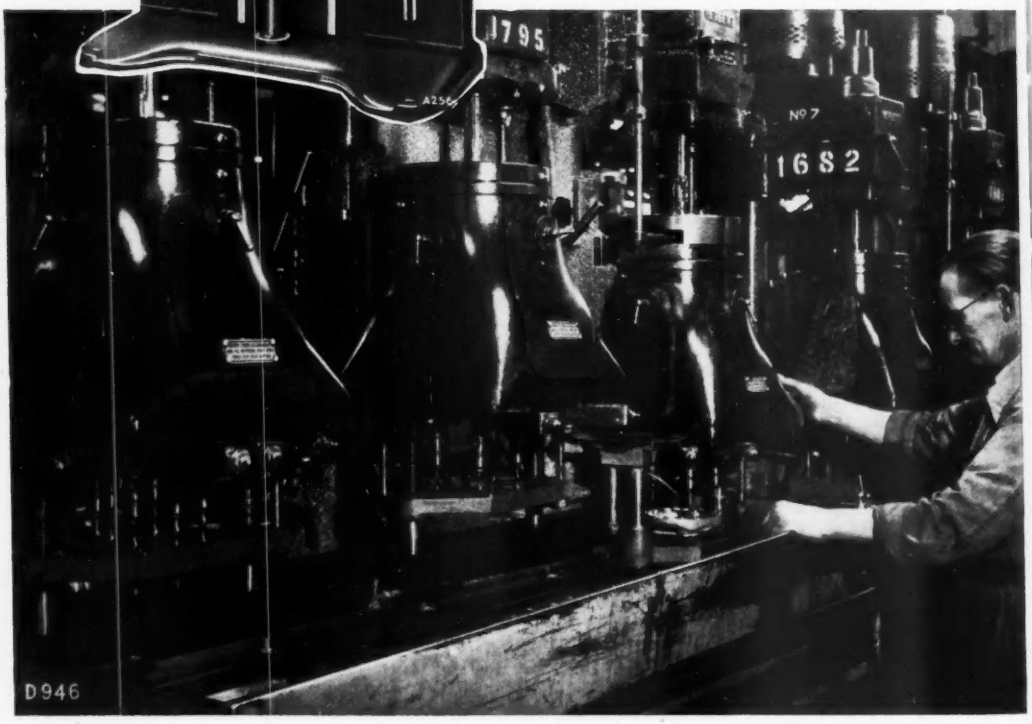

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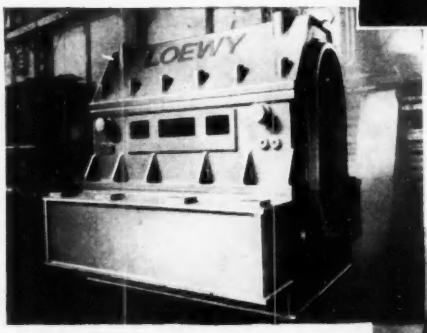

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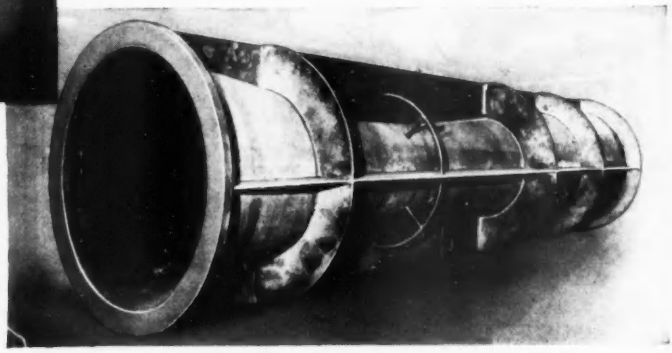

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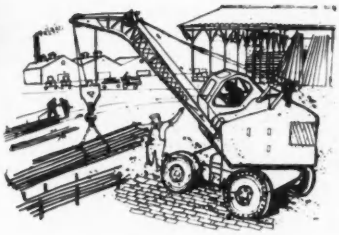

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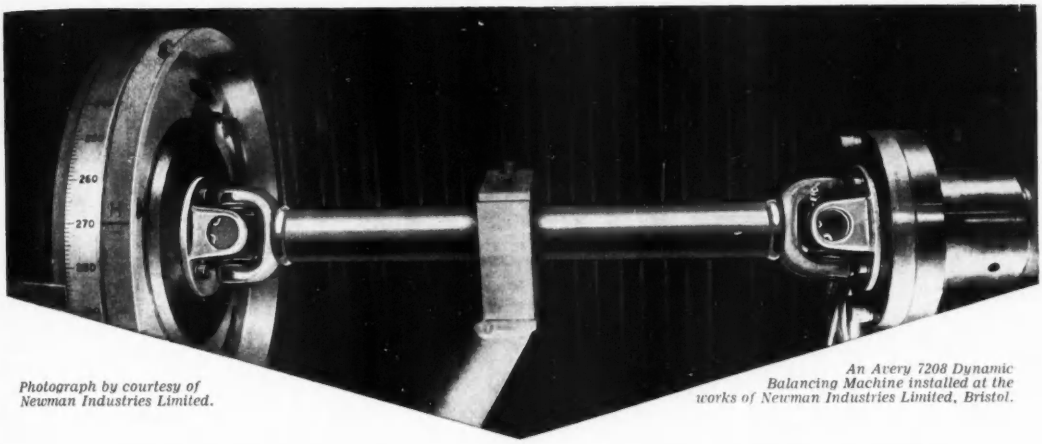

Photograph by courtesy of Newman Industries Limited.

An Avery 7208 Dynamic Balancing Machine installed at the works of Newman Industries Limited, Bristol.

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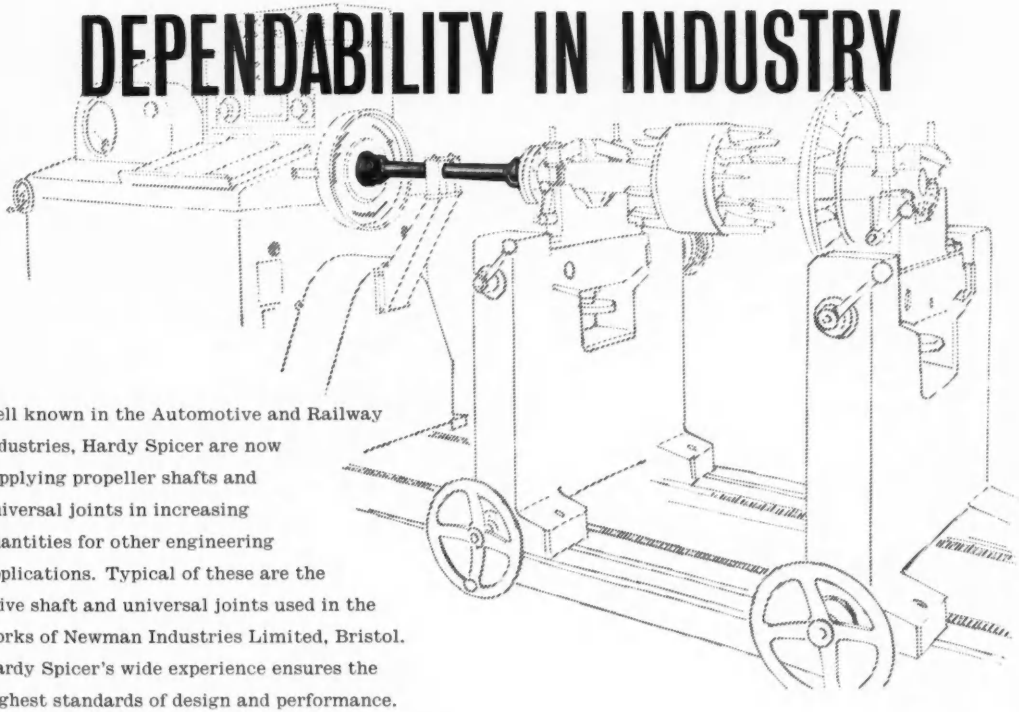

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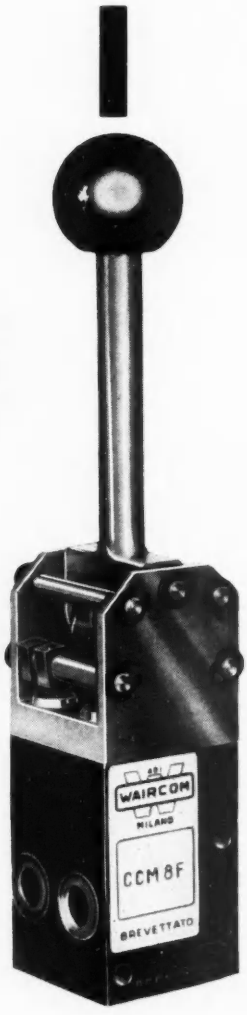

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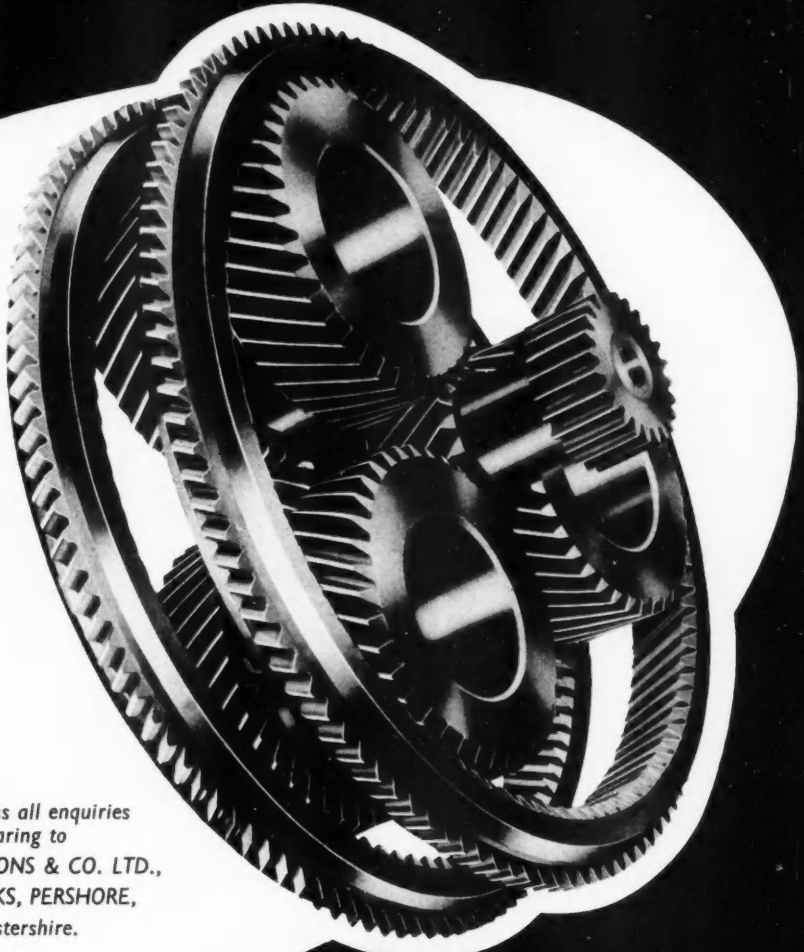

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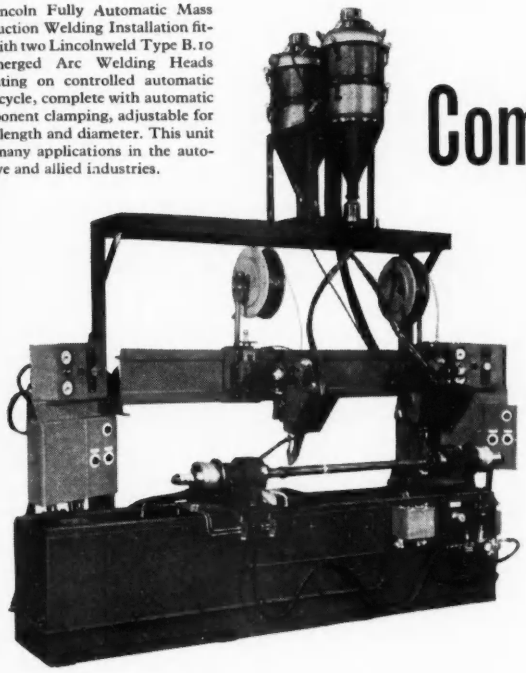

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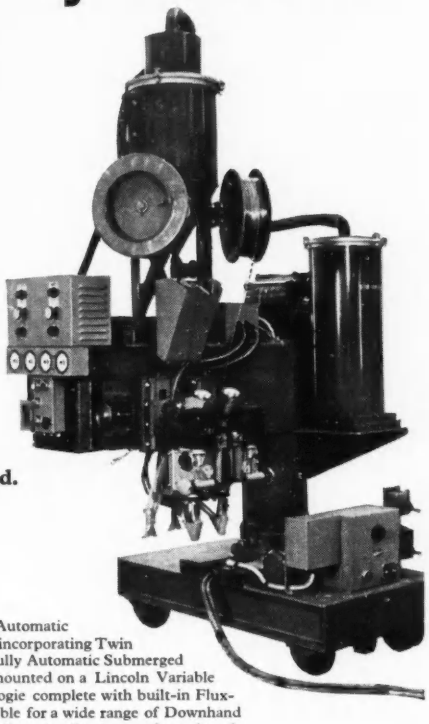

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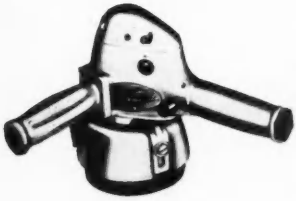

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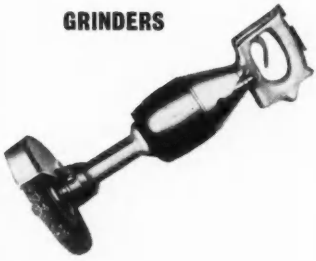

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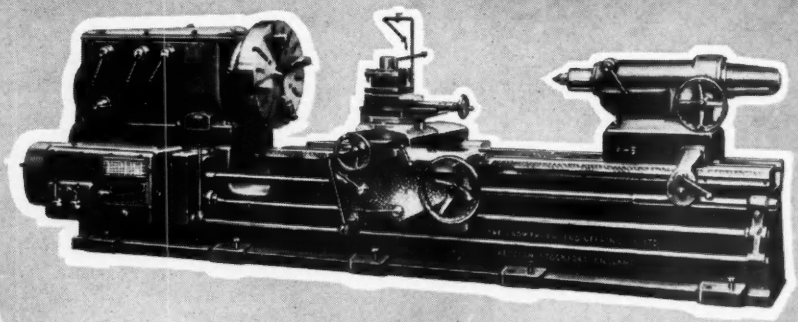

Crowthorn 18 in. Centre Lathe on 15 ft. 3 in. gap bed, admitting 8 ft. 0 in. between centres. Swing over bed 36¾ in. Swing in gap 57 in. × 21 in., hole through spindle 4¼ in. dia. 25 h.p. motor drive.

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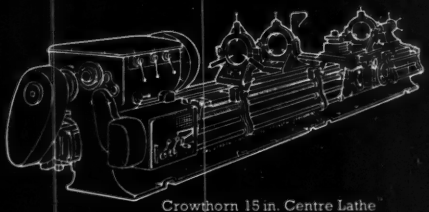

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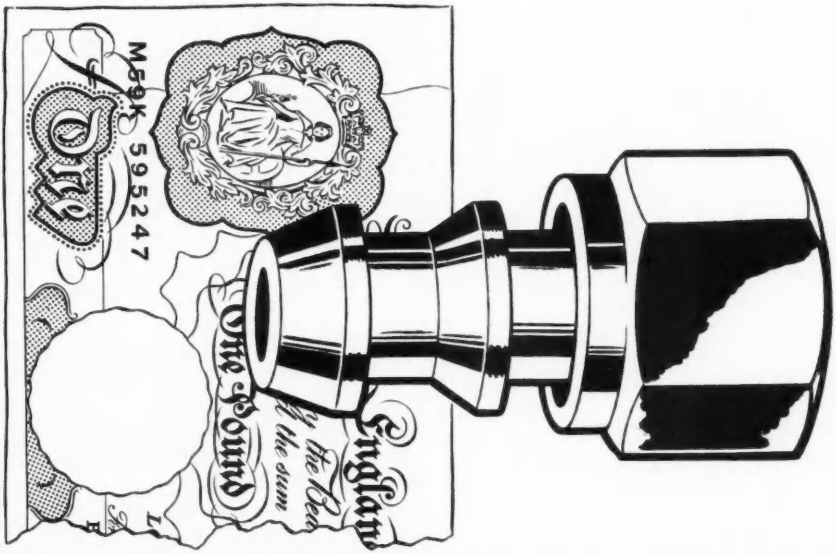

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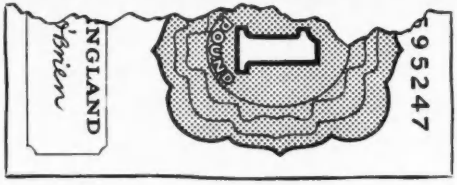

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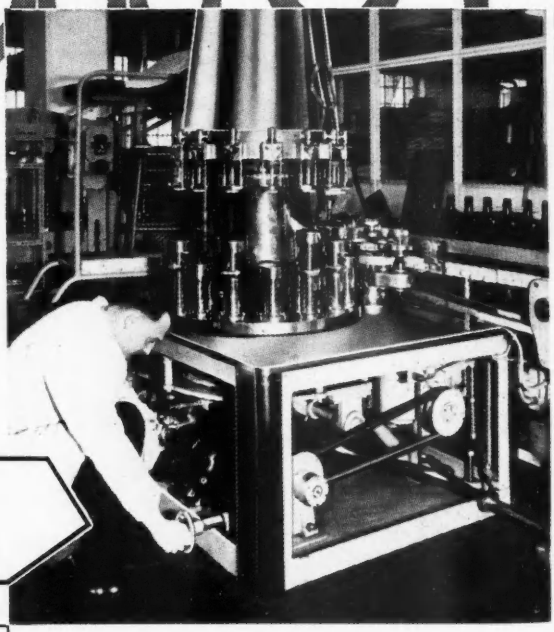

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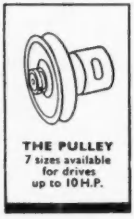

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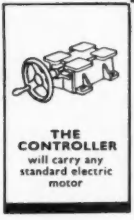

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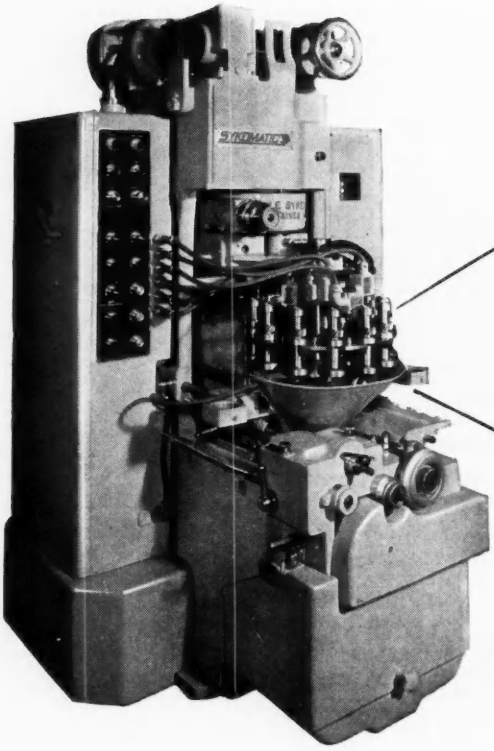

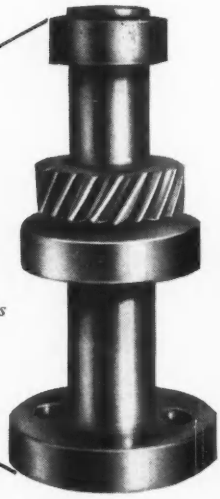

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for a range of components

Magazine loading
one operator can control several machines

Interlocked operating controls
simple, fool-proof operation

Hydraulic chucking and clamping
rigid, vibration-free work holding

Independent setting controls
setting time reduced to a minimum

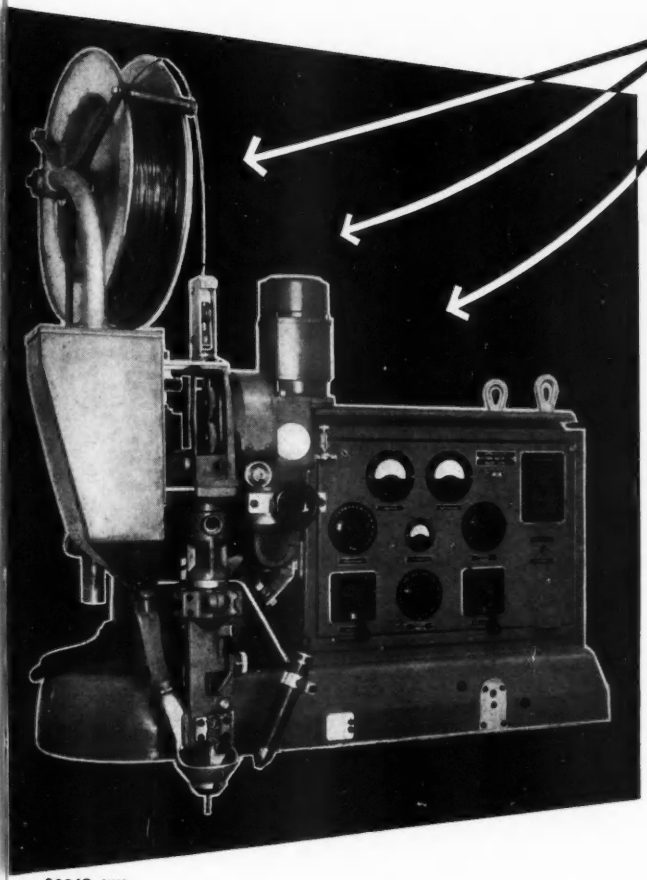
Simple maintenance
plug-in electrical equipment and gasket mounted hydraulic valves

Hopper feed or transfer line equipment
can be supplied if desired

Talk to SYKES about gear production

W. E. SYKES LTD., STAINES, MIDDLESEX, ENGLAND, and associated companies Sykes Tool Corporation Ltd, Georgetown, Ontario, Canada
Sykes Machine & Gear Corporation, Newark, N.J., U.S.A. · W. E. Sykes Ltd., Mascot, Sydney, N.S.W., Australia

Automatic Arc Welder U 1200



90648-VIII

Universally applicable to welding with bare wire, magnetically coated bare wire, commercial coated electrodes and, with submerged arc, for jointing and hardfacing.

Its operation may also be economical in shops not exclusively engaged on mass production.

The new
Automatic Arc Welder Type U 1200
possesses an excellent system for regulating the electrode feed-rate, is easily controlled electrically, has an infinitely adjustable head, and on account of its reliability has been adopted in numerous workshops at home and abroad.

In your works, too,
it can help to

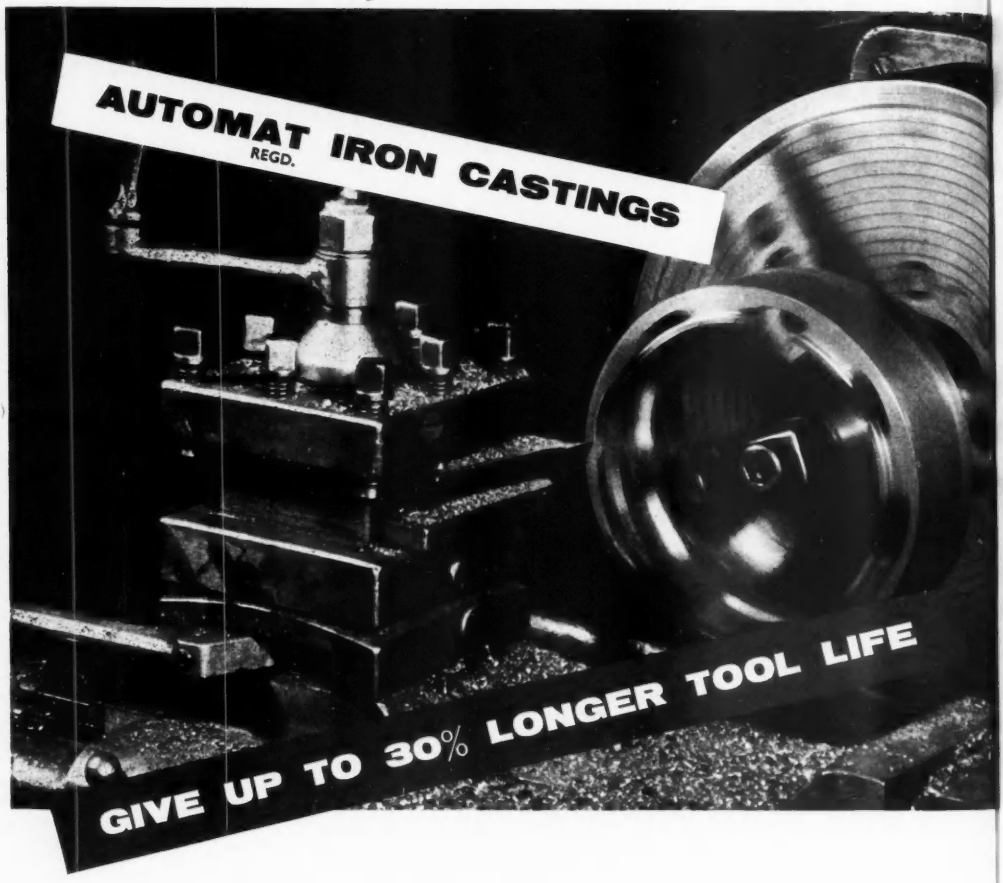
lower costs
increase production
improve quality

Our specialists will be glad to advise you.

BROWN BOVERI

BROWN, BOVERI & CO., LTD., BADEN (SWITZERLAND)

Representatives in most countries.



The inherent resistance to "chill" which is a feature of Automat Cast Iron, removes the danger to high speed machining particularly on thin sectioned castings. One customer increased his turning speeds by 50% and another reported no tool wear after 300 castings had been machined. The result is similar on heavier sectioned castings.

Automat (Regd.) Pig Iron for the production of Automat (Regd.) Iron Castings. Full details available on application.

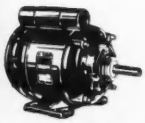
REFINED IRON CO. (DARWEN) LIMITED

SOUGH WORKS, SOUGH ROAD, DARWEN, LANCASHIRE

Telephone: Darwen 1745/6/7. Telegrams: "Rolingot Darwen".

* *Also producers of Darwen Brand Refined Cylinder and Malleable Pig Iron.*

* *Special Alloy Pig Iron and Hi-Carb Iron.*



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...I wanted a shaded-pole motor
I wanted a quiet running motor...
...I wanted a 'fractional' with automatic reset thermal overload protection

Whatever the project, if you are producing machinery to be powered by a.c. or d.c. motors of up to one h.p., consult AEI engineers at the design stage. The wide choice of fractionals they can offer gives you greater scope for producing machinery of improved design and performance. AEI experts have almost certainly met problems similar to yours already, and their valuable experience and knowledge are at your service.

OUR ADVISORY SERVICE FOR DESIGNERS
will save you time and trouble!

Consult AEI engineers *at an early stage* and make sure of getting the *right* f.h.p. motor for the job! Many types and sizes from 1/500 h.p. are available, with every conceivable kind of mounting or fitting, and many of these are available from stock. You can thus combine maximum efficiency and reliability with the most compact, practical, and attractive design.

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Motor and Control Gear Division
F.H.P. MACHINES SALES
NEWCASTLE, STAFFORDSHIRE, ENGLAND

INCORPORATING THE MOTOR AND CONTROL GEAR INTERESTS OF BTH AND M-V

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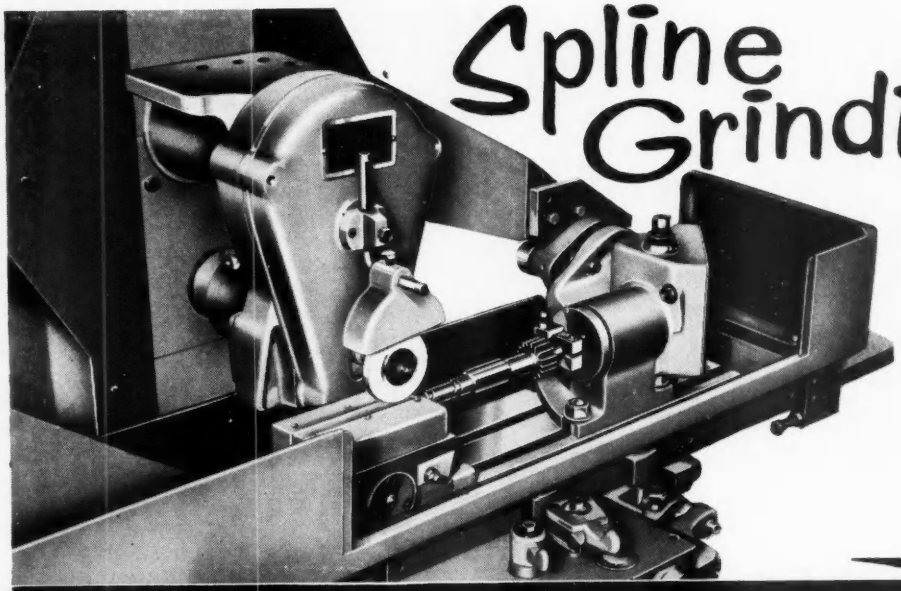
MECHANICAL HANDLING EXHIBITION — STANDS GG13 & GG14



Spline Grinding

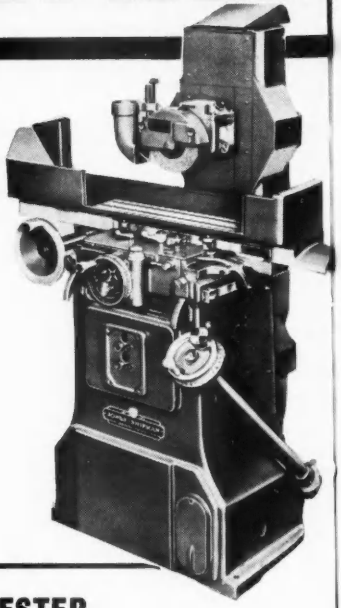
JONES ➡ SHIPMAN

'540' SURFACE GRINDER

The above operation was carried out on a standard Model 540 Surface Grinder arranged with special equipment for grinding the radius at the bottom of four-spline shafts using a formed wheel.

Indexing is automatic. The component turning through 90° each time the machine table moves to the right. The machine is also fitted with a high speed grinding attachment, an optional standard feature for all 540's.

This is one of many adaptations which is possible on these machines, other than conventional Surface Grinding.

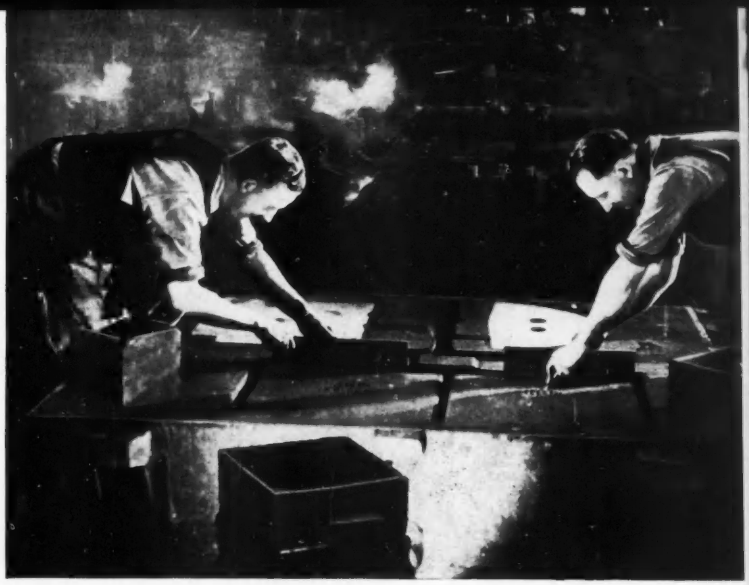


A. A. JONES & SHIPMAN LTD., LEICESTER

Telephone : LEICESTER 823222.

London Office: 50/52 Great Peter Street, London, S.W.1. Telephone: ABBey 5908/9.

NEWTON CHAMBERS



cast in MEEHANITE

Our large modern foundries at Thorncliffe can now produce all classes and sizes of castings in the various types of Meehanite metal. This important addition to our already very extensive foundry facilities enables us to offer an exceptionally skilled and comprehensive casting service. Our long experience of serving almost every major industry gives us a unique understanding of special needs and problems.

Whether you require one casting or thousands, we can meet your needs promptly, in sizes from a few pounds up to 20 tons in weight. Production methods include light, medium and heavy machine moulding, as well as floor, loam and shell moulding. A skilled patternmaking service is at your disposal. Your machining and fitting requirements can be undertaken by our fully modernised machine shops.

All enquiries will receive immediate attention.

Newton Chambers

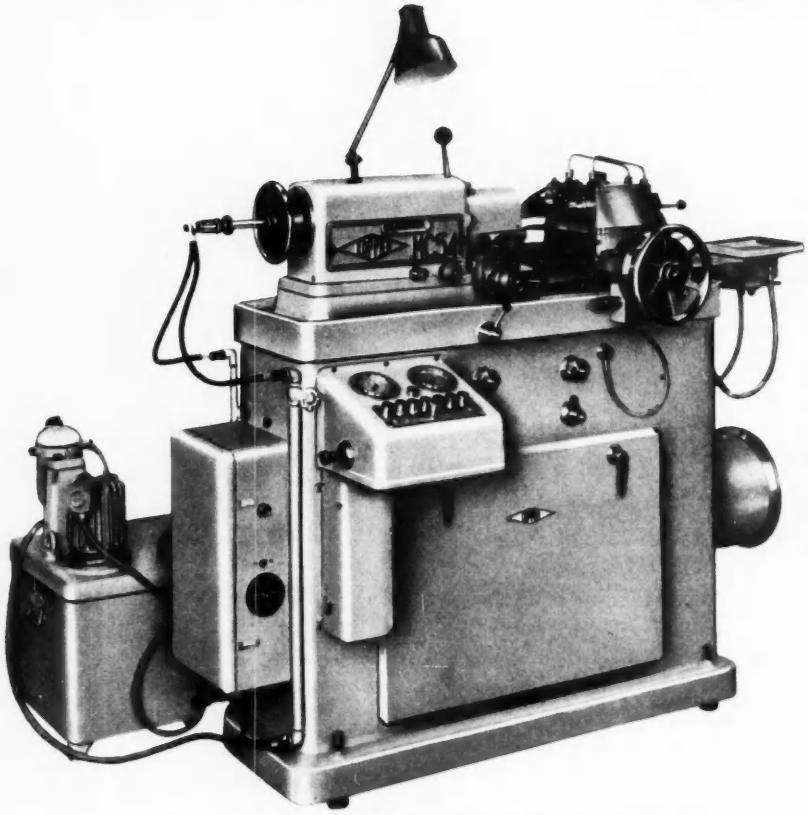
ENGINEERING DIVISION · THORNCLIFFE · SHEFFIELD

ENGINEERS OF PROGRESS

INTERNAL GRINDER

for production of Injectors
and high-precision components

FRATELLI COPPIER MILANO



TECHNICAL CHARACTERISTICS

Internal grinder for holes of 1 to 20 mm diameter in high-hardness alloys, e.g. gauges, dies, etc. Spindle Speeds from 60,000 to 140,000 rpm.—Quick adjustment for control of diameters, with automatic feed of the spindle head: automatic stop — Supply voltage according to requirements. Weight of complete Grinder approx. 750 kg.

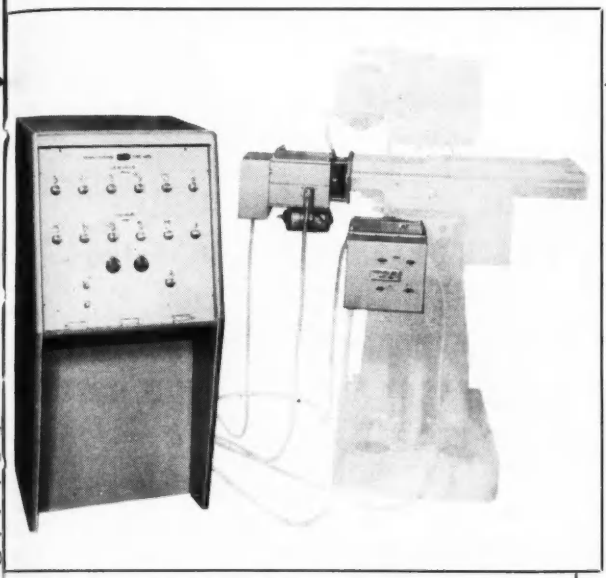
CONSTRUCTIONAL FEATURES

Grinder specially designed for the mass production of injectors of any type, for the internal grinding of gauges and dies in tungsten carbide and other alloys, for work requiring a very high degree of precision of the order of 0·0003 mm both in roundness and centricity with surface micro-roughness of 0·00025 mm. Perfectly smooth surfaces are obtained, in view of the complete absence of harmful vibrations. The perfect finish of the surfaces, combined with exact geometrical shape, is always assured by the M.C.54 Grinder fitted with patented M.C.52 "Turbo Spindles", with automatic take-up of bearing play, oil-mist lubrication, and other features introduced into its construction. All the adjustments of the individual members of the machine are hydraulically controlled. The machine is fitted with turbine-driven spindles of very high rotational speeds, from a minimum of 60,000 to a maximum of 140,000 rpm; one of these spindles serves to grind cylindrical parts and the other to grind conical parts (e.g., injector and valve seats) according to requirements.
The rotating spindle unit of the M.C.52 "Turbo Spindles" employ a small turbine and the hydraulic system adopted, as compared with electrically-driven spindles, affords numerous advantages, including the following :—

- simplicity of construction.
- variable speed range between the limits required, depending upon the internal dimensions to be ground.
- normal operating speed : 120,000 — 130,000 rpm
- speed variation between full and no load about 3-4%.
- extremely simple automatic lubrication, without the need for cooling equipment.
- possibility of grinding diameters from 1 to 20 mm.
- automatic take-up of bearing play by means of a patented device which guarantees longer life to the bearings.
- operating life of the spindle at least 800 working hours guaranteed.
- high-precision grinding and finishing of the parts.

FRATELLI COPPIER-MILANO (ITALY) PIAZZA CARRARA, n.15

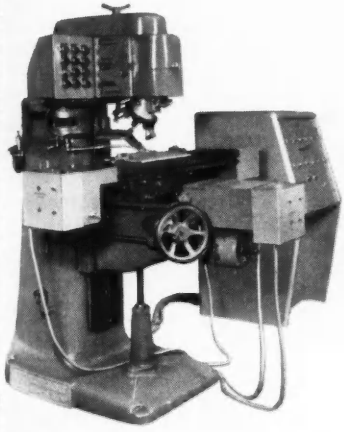
'Phone: 84.90.386



AIRMEC

If it's a case of making a hole— Do it automatically with the

AIRMEC AUTOSET



Autoset fitted to Vero Auto-drill. 6 Spindle Turret Head — 32" × 9" table. Spindle speeds 300-6000 rpm — $\frac{5}{16}$" drill capacity. Full details available from Catmur Machine Tool Corpn. Ltd., 103 Lancaster Rd., London, W.11.

SEE THIS INSTRUMENT AT THE I.E.A. EXHIBITION, OLYMPIA, MAY 23—28, STAND D162.

POSITIONS THE WORK
Autoset Automatic co-ordinate setting equipment provides accurate automatic control of the lead screws of a co-ordinate table. It enables the table to be positioned automatically by means of a punched tape (containing co-ordinate information for up to 600 operations) or manually by means of a series of knobs and dials.

SELECTS THE RIGHT TOOL
Facilities are provided for selecting one of up to ten tools and for controlling a large number of other variables such as tool feed rates, feed depths and spindle speeds.

ROBUST AND RELIABLE
No electronic valves used.

EASY MAINTENANCE

CUTS OUT ERRORS
Autoset is highly accurate—automatic compensation is provided for table backlash and cumulative lead screw errors.

CUTS THE COST
A complete equipment for automatic control in two dimensions including tape punch costs only £1,500. Manual control considerably less.

Descriptive leaflet No. 186 sent on request

AUTOSET
LOW COST TAPE CONTROL

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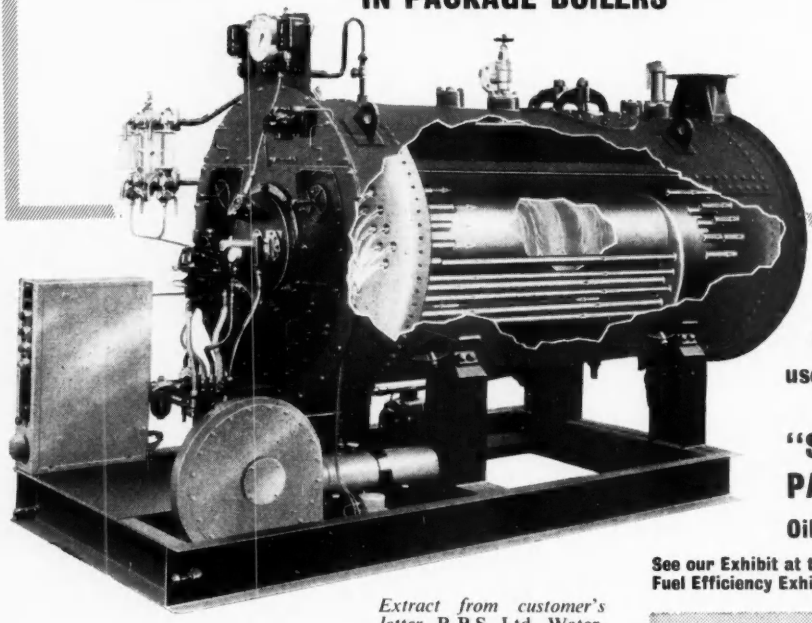
SEPARATE REAR TUBE PLATES AND WATER COOLED COMBUSTION CHAMBERS ARE NOT NEW. THE CRADLEY STEAMPACKET INCLUDED THIS IMPORTANT FEATURE IN 1954. WITH THIS IS COMBINED THE CRADLEY/RUDLING OIL BURNER WITH ITS AMAZING FLAME AND ALL ROUND RELIABILITY. "STEAMPACKET" REMAINS THE BEST IN PACKAGE BOILERS



for efficiency and durability

use a British designed and built

"STEAMPACKET" PACKAGE BOILER

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Smoke fouls the atmosphere and is a sign of INEFFICIENCY in a boiler! The best answer to smoke pollution is a Cradley *Smokeless* oil-fired boiler. Over 80% efficient. Combustion Chamber overheating and rapid wear of rear fire bricks cannot occur owing to water-cooled combustion chamber and separate rear-tube plates. To evaporate 1,010 lbs. to 10,500 lbs. per hour from and at 212°F.

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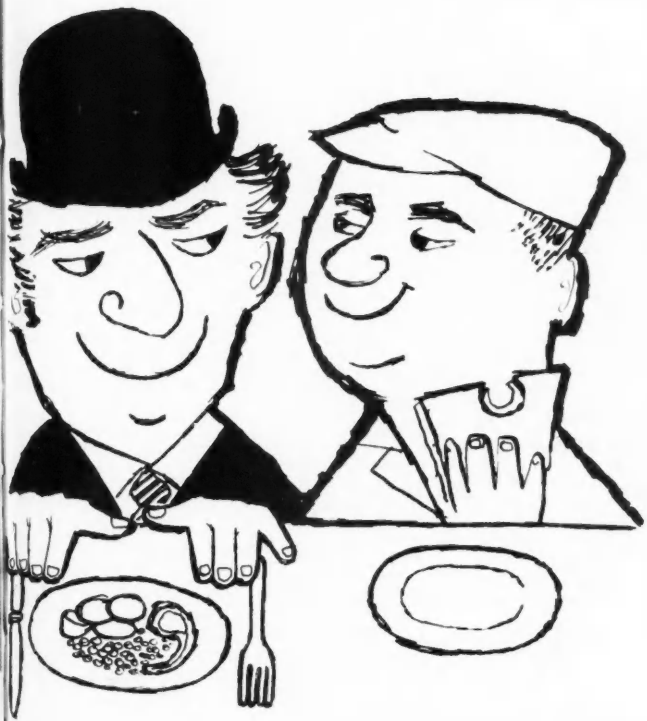

WE OFTEN TALK 'SHOP' AT LUNCH

(Because we like to thoroughly digest our customers' problems!)

We like to see a job well done. And we like to see our customers happy!
Getting our teeth deeply embedded into our customer's problems—no matter how specialized and individual—is the backbone of the MVC Service!

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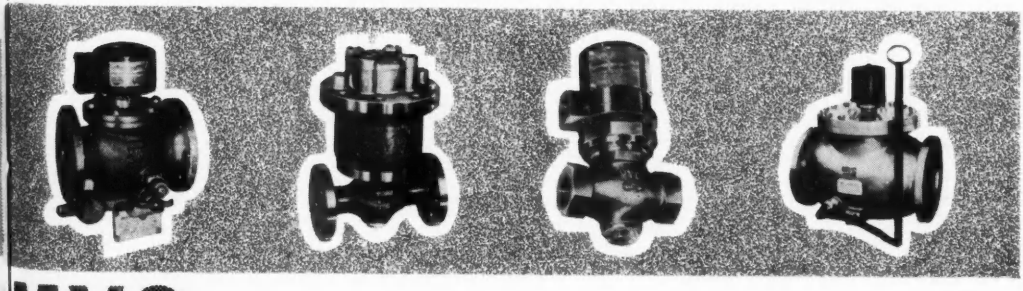
You'll find that expert consultation and advice cost you absolutely nothing at MVC. Our full experience is at your disposal. Many times, what has first appeared to be impossible has been achieved. Why not write *now* for our new comprehensive catalogue No. 23 which contains full details of our complete range!



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The Magnetic Valve Company Ltd

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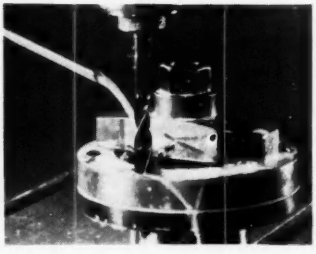
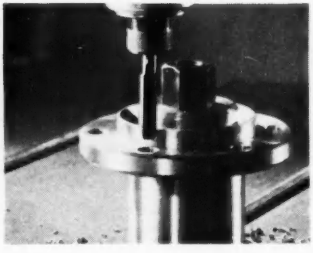
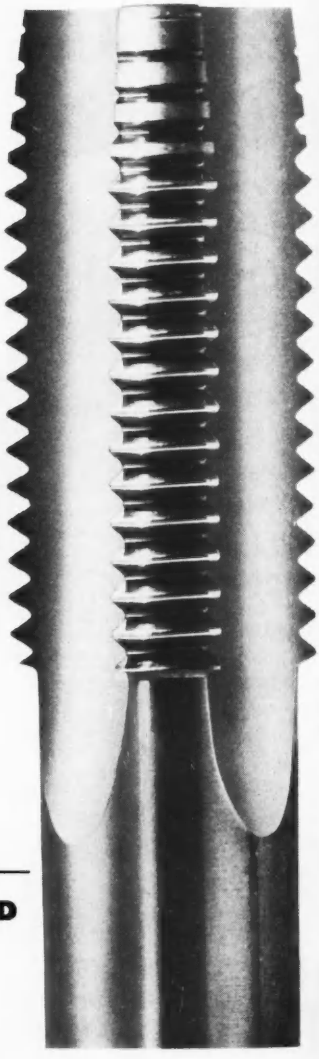
Drill and Tap with EaSiCut







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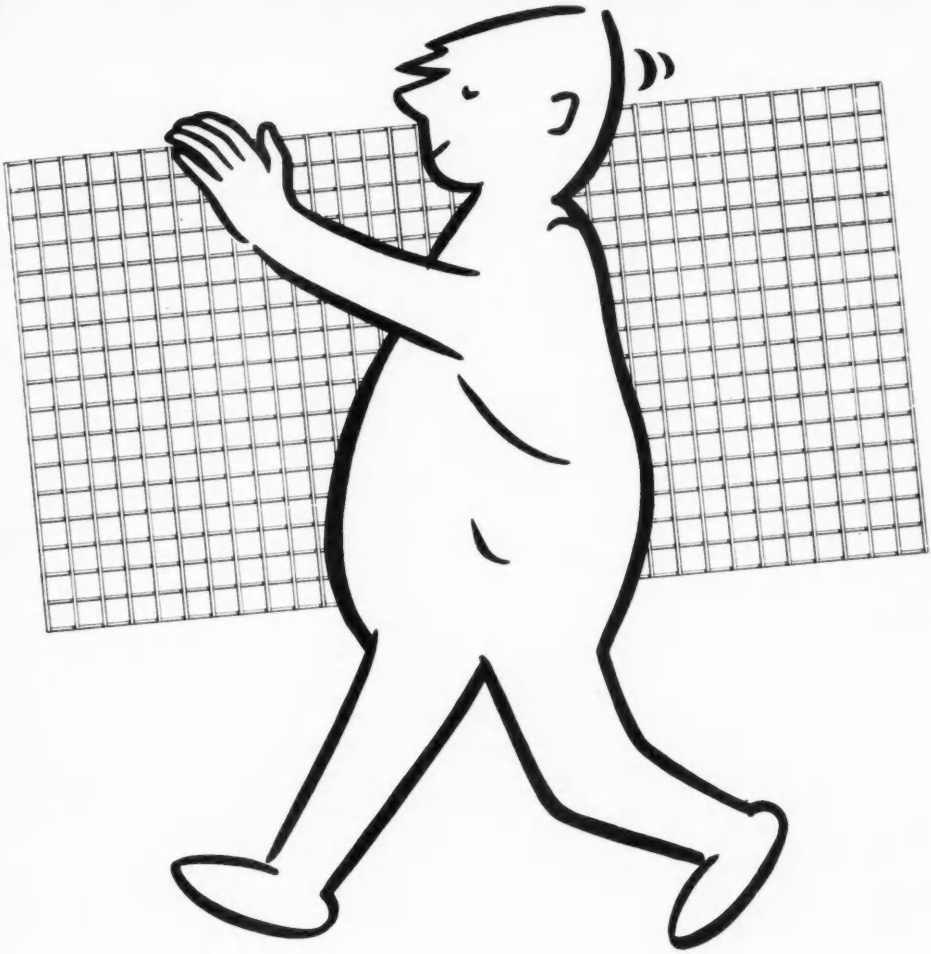

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solving his partitioning problems with

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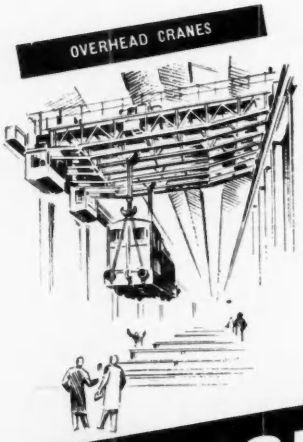

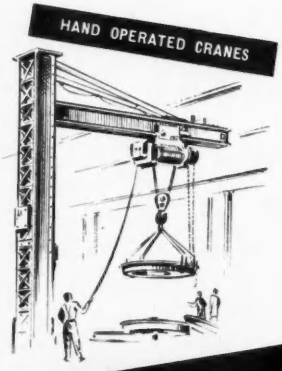

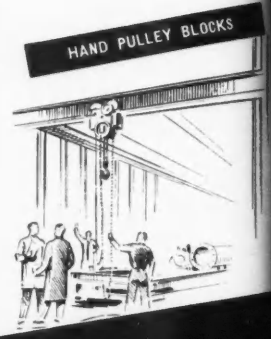

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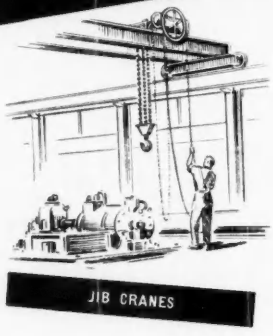

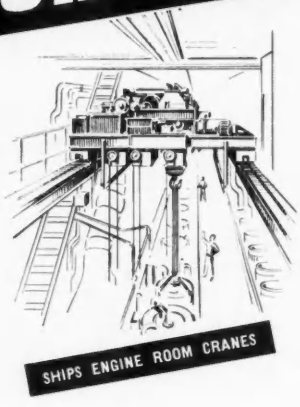

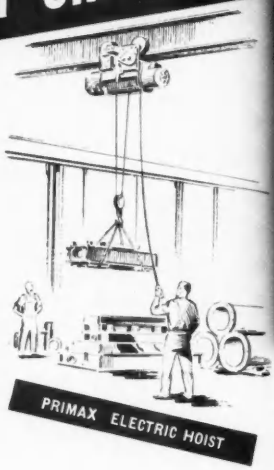

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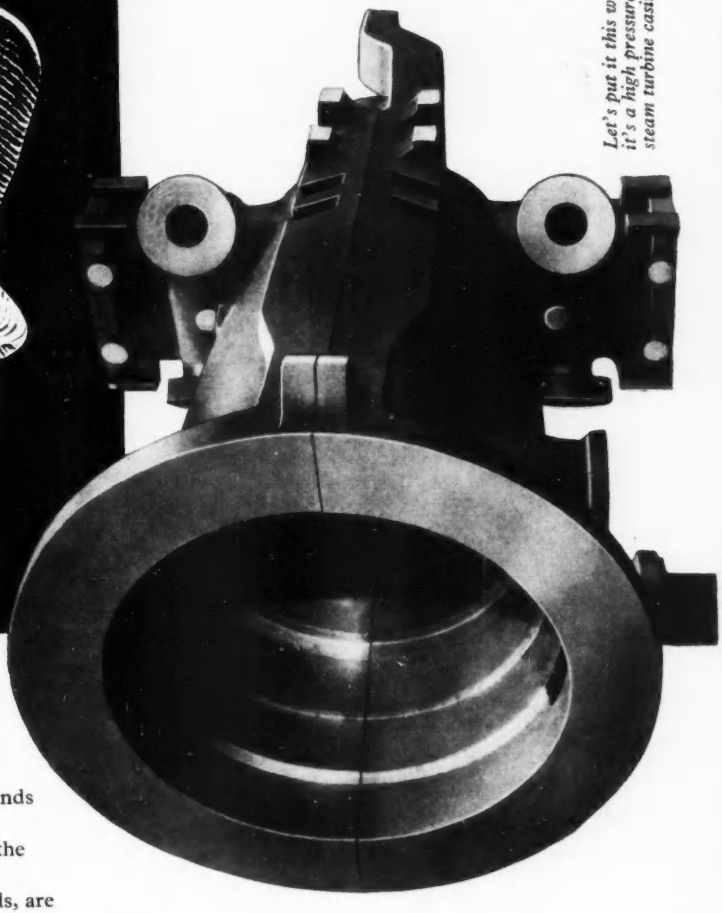
Brown Magic



Let's put it this way — it's a high pressure steam turbine casing.

There is no witchcraft, really about the unvarying high quality of David Brown castings — though there are many other kinds of craft involved in their production. At the Penistone Foundries, the craft of the steel maker, pattern maker and moulder are brought together and, with other skills, are co-ordinated into a complex production unit of supreme efficiency. Backed by unique metallurgical resources and using the most up-to-date plant and techniques, this organisation offers a completely reliable service for all types of steel casting. Next time you have a casting problem, whatever the application, call in David Brown — first!

DAVID BROWN

THE DAVID BROWN CORPORATION (SALES) LIMITED

FOUNDRIES DIVISION PENISTONE, NR. SHEFFIELD. TELEPHONE PENISTONE 3311

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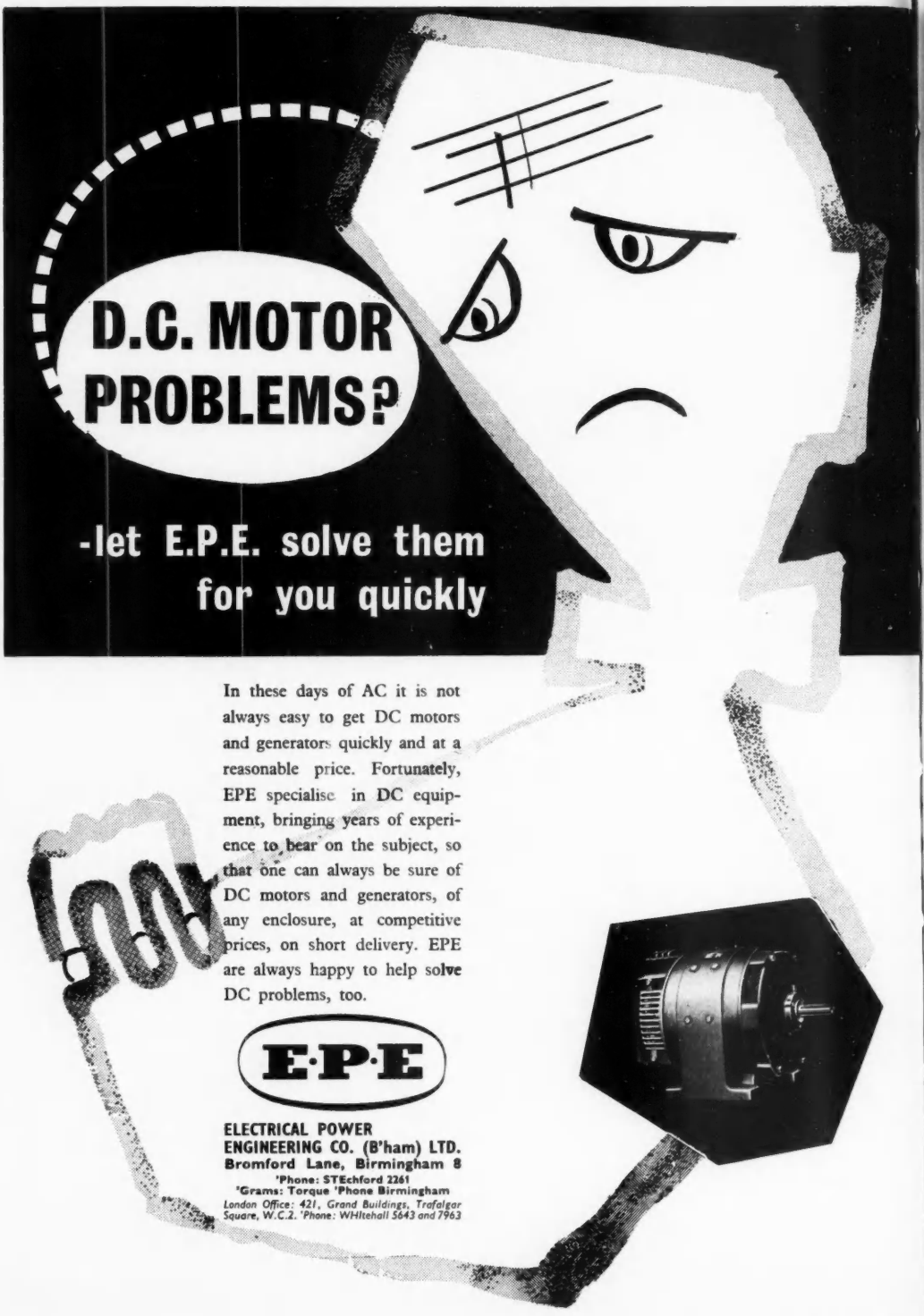
-let E.P.E. solve them for you quickly



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E·P·E

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Bromford Lane, Birmingham 8
'Phone: STEchford 2261
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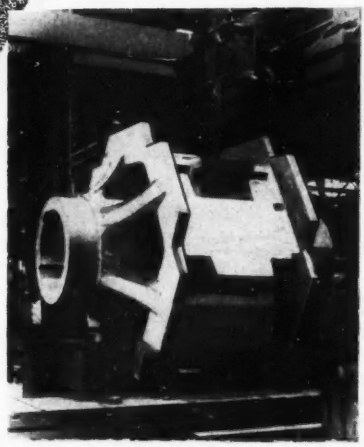
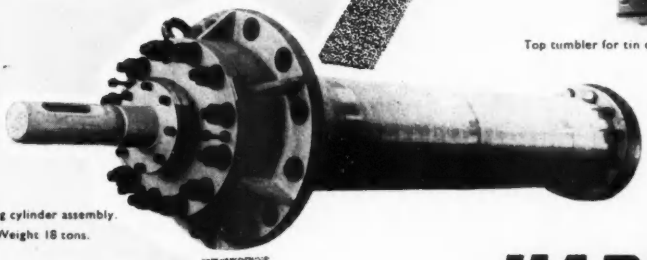
Best quality steel castings have many applications which offer certain economical advantages over other production methods. Before finalising your requirements **THINK OF CASTINGS FIRST** and consult Hadfields . . . . . a name for Steels in **CARBON—LOW ALLOY —STAINLESS—MANGANESE— WEAR RESISTING—HEAT RESISTING STEELS.**



Top tumbler for tin dredging. Weight 17¼ tons.



Tilting cylinder assembly. Weight 18 tons.

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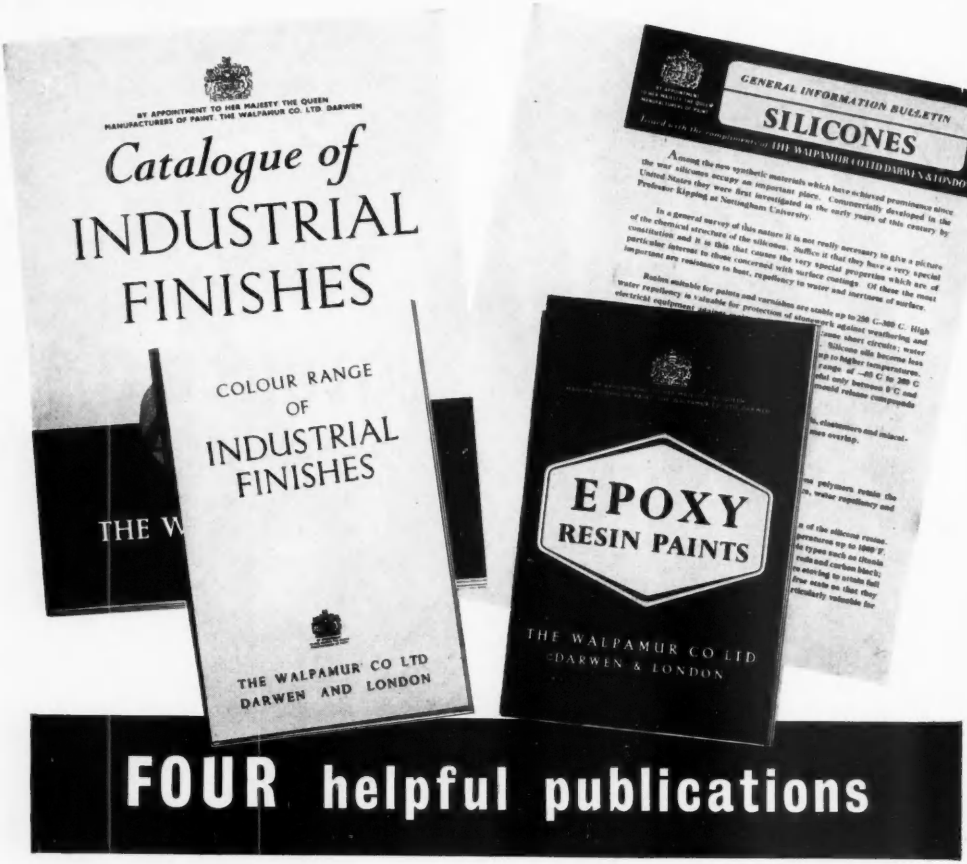

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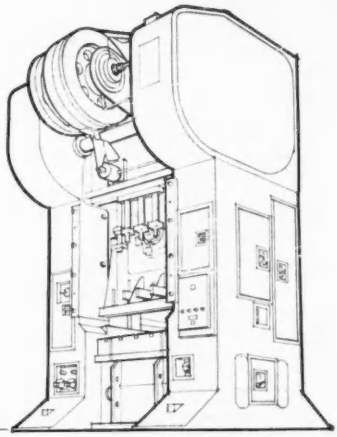

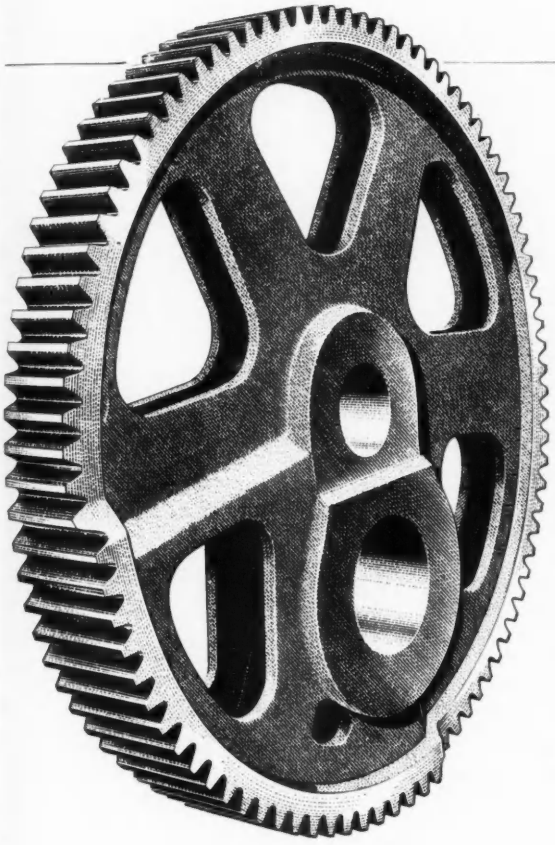

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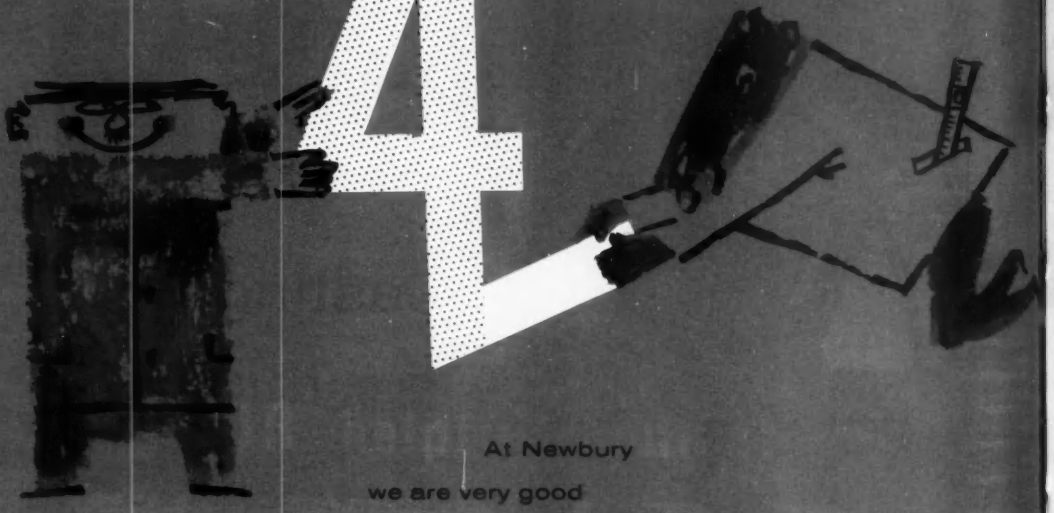

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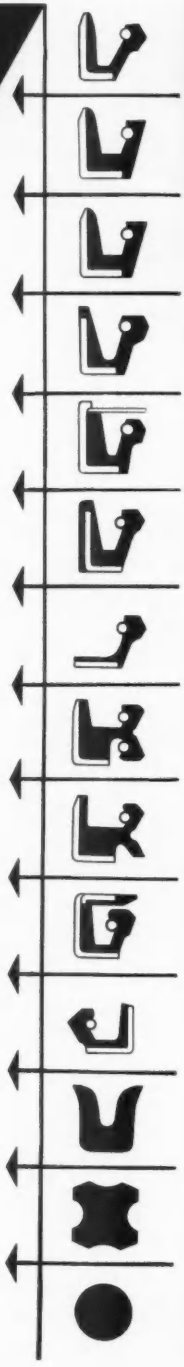

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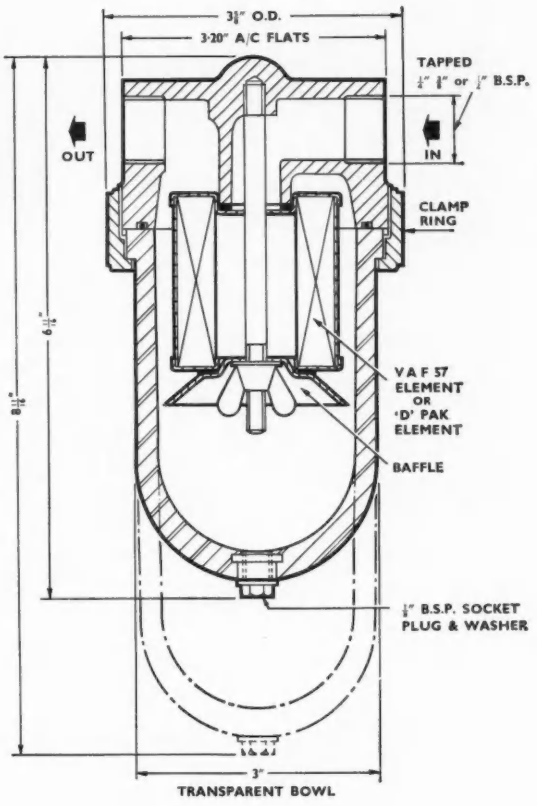

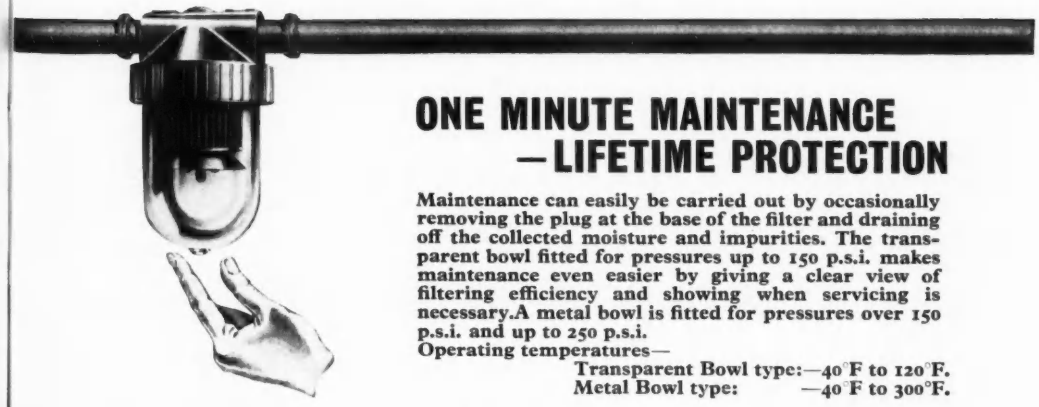

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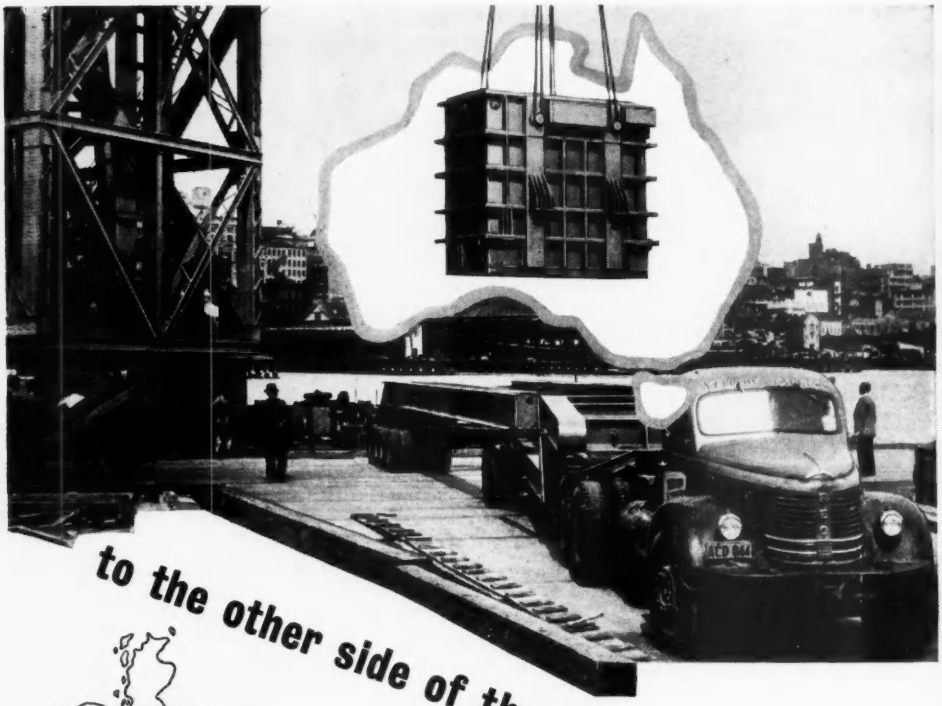

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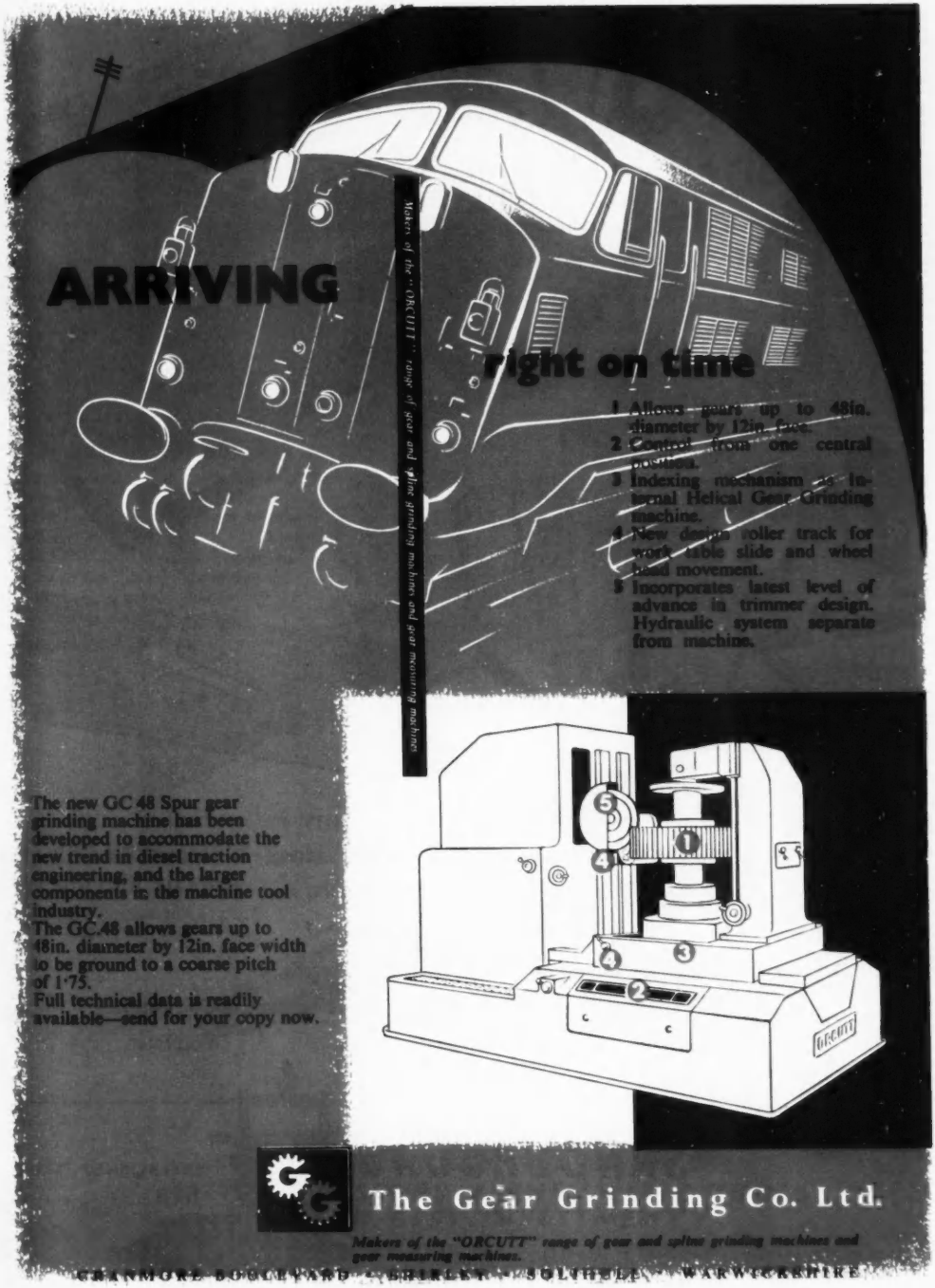

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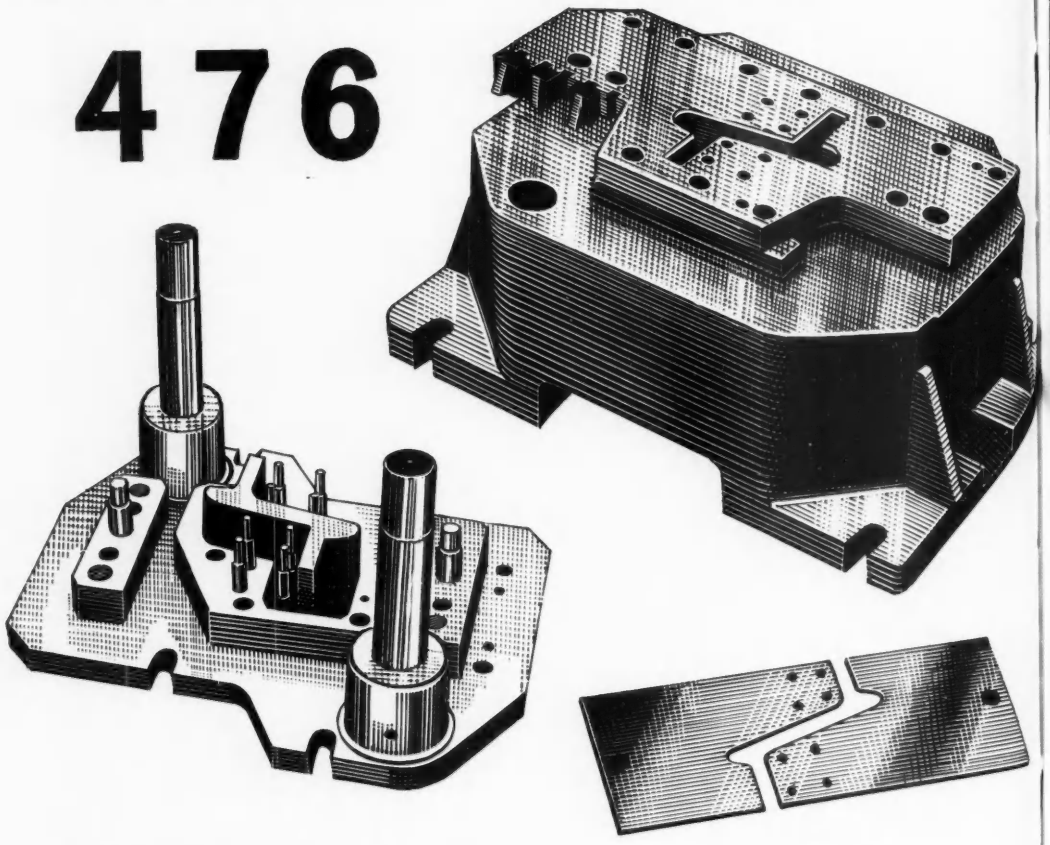
476



'476' Heavy duty die steel of the high carbon, high chromium type, has outstanding wear-resistance but is tough and machinable. It is particularly recommended for tools operating under conditions of severe wear and abrasion and where maximum runs are required.

The above illustrations show a punch and die set produced from '476' steel by The Mining Engineering Co. Limited, Worcester.

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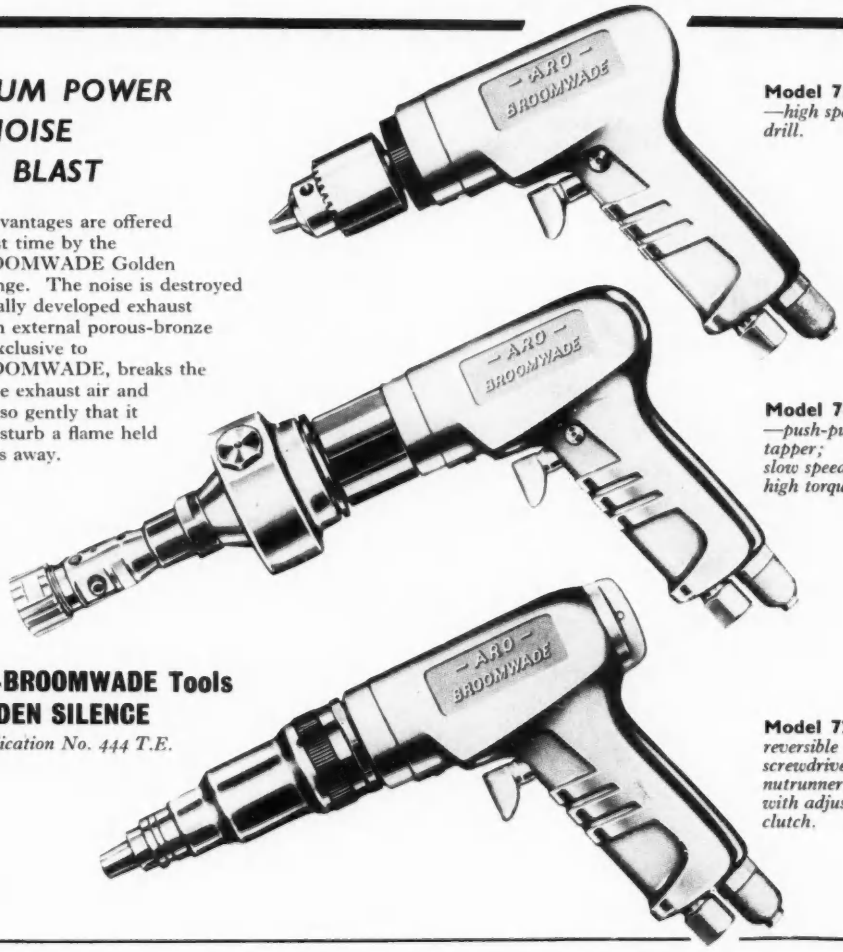

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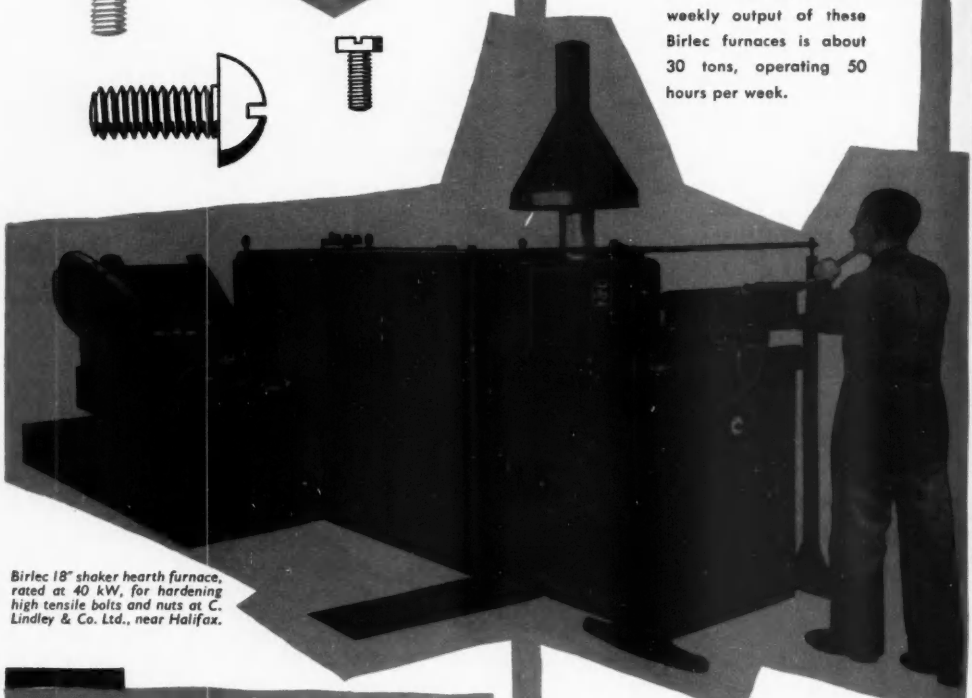

Birlec 18" shaker hearth furnace, rated at 40 kW, for hardening high tensile bolts and nuts at C. Lindley & Co. Ltd., near Halifax.

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A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

• *NEW WEAR-RESISTANT TUNGSTEN STEEL*

A recently patented tungsten steel is claimed to possess superior wear resistance at room temperature than high-carbon, high-chromium steels, because its tungsten content is combined with carbon, producing tungsten monocarbides. Containing 1·5% carbon, 2·0% manganese, 0·25% silicon, 0·9% chromium, 1·0% molybdenum, and 4·0% tungsten, the new alloy can be hardened in air from a temperature of 1550°F, provided that the cross-section is 2 in. or less in diameter. This relatively low heat-treatment temperature for such a deep-hardening steel confers additional advantages. Thus, the furnace required for hardening the material is the same as that used for the normal hardening of carbon and low-alloy steels, as the furnace temperature need not be higher than 1600°F, whereas high-carbon, high-chromium steels may require up to 1875°F. Furthermore, at the lower temperature used, control of furnace atmosphere is easier, and the decarburization reaction is slower. Salt baths of the type used for the hardening of plain carbon steels can also be used, if desired.

In the quenched state, the new alloy has a high hardness, i.e., R_C 65 to 66 for samples which have been oil-quenched from 1450°F or R_C 66 to 67 from 1500°F. With air-cooling from 1550°F, the hardness value is from R_C 62 to 63, and R_C 65 to 66 from 1600°F. For most purposes, however, the optimum tempering temperature is around 350°F, the corresponding hardness value being R_C 64, with minimum distortion and maximum toughness. Since there is little tendency for secondary hardness to develop, the normal maximum operating temperature for the alloy is also 350°F.

From *Steel*, U.S.A.,
January 18, 1960, pp. 100–101.

• *COMPUTER-CONTROLLED ROLLING MILL*

When a single-stand reversing mill is used for rolling an ingot to a slab, or a slab to a plate, so as to reduce the thickness of the rolled material from pass to pass with little or no increase in the width, the gap between the mill rolls is reduced after each pass to give a draft, i.e., a specific reduction in thickness, to the material. The degree of draft is at present determined by the operator, who relies upon his experience, and it is necessary to vary the draft as rolling conditions change. In present rolling practice there is very little equipment to assist the operator in the assessment of draft, and the loading on the mill in terms of roll-separating force or driving-motor torque can vary over wide limits if the materials to be rolled vary in composition, width, and working temperature from piece to piece, as commonly happens.

For each pass there is an optimum draft, i.e., that which will give the maximum tenable mill load or roll-separating force, and this depends on the composition of the material, its width, and the temperature. In this connection, a recent patent is based on the utilization of a mathematical relationship which has been determined between the roll-separating force in consecutive passes and the draft in these passes. A computer can be designed or set for continuously solving the equation expressing this relationship, and the set-up will then consist of a computer in combination with the mill. The signals are fed to the computer by means of an instrument responsive to the roll-separating force and an instrument responsive to the roll gap as set. There is also an instrument set by the operator to feed a signal corresponding to a desirable predetermined roll-separating force. Preferably, another instrument is included for feeding a signal corresponding to the thickness of the material, before or after the first pass.

From *Brit. Patent Spec.* 818, 952,
United Steel Companies Limited, Sheffield, England.

• *THE CRYOGENIC GYROSCOPE*

Operating at a temperature near absolute zero, a cryogenic gyroscope now under development utilizes magnetic fields both to float and to spin a superconductive sphere at high speed in a vacuum. Electrical and frictional losses are virtually zero, so much so that, once set in motion, the sphere will continue to rotate indefinitely. Because it eliminates the common causes of errors in conventional gyroscopes, it is expected that the cryogenic gyroscope will prove to be many times more accurate. Thus, the elimination of mechanical bearings and the reduction in frictional and electrical losses are conducive to increased accuracy, while the dimensional stability conferred by the well-regulated cryogenic temperature should also make it more reliable.

It is, of course, well known that a current in a superconductive coil at temperatures near

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absolute zero continues to circulate almost indefinitely, producing a magnetic field that is virtually constant, and the new gyroscope utilizes this " frozen " field to float its superconductive rotor. A magnetic field of less than a critical field strength cannot penetrate a superconductor; rather, the superconductor acts as a magnetic insulation, repelling and shaping the field around itself. However, in the same way as the superconductor repels the field, so also does the field repel the superconductor, i.e., it tends to force the superconductor away. Spinning of the gyroscope rotor is caused by torque produced by a secondary magnetic field, very little power being consumed in the process because, once the rotor is up to speed, its losses are almost zero. An experimental rotor designed on these principles has already been operated at speeds of 20,000 rpm for extended periods.

From *Machine Design*, U.S.A.,
February 4, 1960, pp. 14–15.

● ***TYRE TESTING***

The widespread adoption of nylon as a tyre cord and the substantial improvements made in the properties of both nylon and rayon tyre yarns in recent years are a direct result of the extensive research and development programmes carried out by tyre manufacturers and fibre producers. Tests carried out by the fibre producer have an objective somewhat different from that of the tyre manufacturer. While both need an overall evaluation of the performance of specific tyres under various conditions, the fibre producer must seek knowledge as to what is happening to the fibre during tests, so as to be able to improve the fibre.

Testing of tyres thus becomes primarily a method of subjecting the fibre to the kinds of stresses, strains, and temperatures met in actual service. The test methods described in a recent paper are therefore concerned with tyre cord strength, fatigue resistance, and heat resistance. Since the maximum strength of a tyre in actual service is only tested when it strikes some object while moving, a dynamic test was adopted, in which the impact resistance is measured by running the tyre to failure on an indoor test wheel equipped with a plunger which strikes the tyre once per revolution. The impacts are delivered randomly around the circumference of the tyre, and, in order to make certain that no patterning occurs, the tyre is withdrawn from the wheel for about three seconds every ten minutes. This permits the tyre speed to change slightly with respect to the test wheel, so that the impacts are delivered in new positions around its circumference.

The crown impact endurance test has been very useful for evaluating new or improved fibres, both in comparing the overall tyre impact resistance level which can be achieved and in determining the denier or cord gauge at which the fibre will give optimum performance. As regards fatigue, a flex test has been found to provide comparative indices of fibre performance by the direct measurement of strength loss produced by repetitive flexing, whilst a high-speed endurance test has proved a useful method for evaluating fibres in high-speed high-temperature service.

From *Transactions of the ASME*, U.S.A.,
Series B, February 1960, pp. 23–28.

● ***HIGH-TEMPERATURE HIGH-STRENGTH TANTALUM ALLOY***

Containing from 5 to 20% chromium and from 2 to 25% tungsten, a recently patented tantalum alloy can be hot-worked and is highly resistant to oxidation or other forms of corrosion at temperatures up to about 2000°F and even higher, combined with high mechanical strength at these elevated temperatures. As a result, it can be used for the blades, vanes, and other parts of high-temperature gas-turbine engines, or for exhaust valves and manifolds in internal combustion engines, in heat exchangers, and in linings for retorts and containers used in the chemical and metallurgical industries.

In the past, it has been generally accepted that the metals columbium and tantalum are substantially equivalent. It has now been found, however, that such is not the case. Thus, for example, a relatively small proportion of chromium as an alloying constituent with columbium and tungsten makes the resulting alloy too brittle to be of any practical value, even when using as much as 25% of tungsten. On the other hand, up to 25% tungsten and substantially larger percentages of chromium can be alloyed with tantalum, the resulting alloy possessing unexpectedly improved properties, as already indicated. To achieve optimum properties, the new tantalum alloy should not contain more than 0·5% carbon, and the oxygen content should not exceed 0·8%, the nitrogen content 0·2%, and iron content 5%.

From *Brit. Patent Spec.* 829, 733,
Sierra Metals Corp., Chicago, Ill., U.S.A.

● ***AUTOMATIC POWER-SWING ANALYSER***

The application of network analysers in power-system studies not only eliminates to some extent tedious computations, but can also take into consideration the inherent resistances of the transmission lines. Nevertheless, the computations involved in the transient stability studies required are still very complicated, even with the use of an analyser. The accuracy of the conventional point-by-point solution of the swing equation mainly depends on the time interval used and, for simplification, the damping

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term in the swing equation is usually neglected. It is not surprising, therefore, that workers in this field have been looking for new methods to facilitate their computations, and it is interesting to note in this connection that an automatic device for computing power swings in electrical networks has now been developed which should considerably ease the task of investigators. In fact, it is claimed that the development of this computer can certainly be considered a useful contribution to hitherto available tools for power-system studies, as far as the simplification of the stability computations for a complicated power system is concerned.

The new computer is a continuously acting analogue computing device and can take into consideration many factors which can hardly be taken into account in an ordinary network analyser, while the results of computations it can carry out can approximate much more closely to actual conditions. The development of the new device is considered to be only the first step in the automatization of the network analyser, and may be further extended to the automatic control and exact analogue of the generator, line, and load units, as well as of the voltage- and frequency-regulating devices. If this is achieved, the mathematical analogue will be able to compete with, and possibly will be more flexible than, the physical analogue.

From *Science Record, Pekin*, China.
February 1960, pp. 133–138.

THE "TWIN-PLANETARY" EPICYCLIC GEAR

In epicyclic gear trains requiring the transmission of a given torque from a central sun gear to a large internal gear by means of one or several planetary gears mounted on a common carrier, the unfavourable loading of the planetary gears presents a common difficulty. Thus, an arrangement with one planet gear severely limits the transmissible torque, whilst, because of unavoidable tooth errors, several planet gears mounted rigidly on a common carrier cannot share the load equally. Elastic rubber bushes are not satisfactory in the long run, and a design with flying, self-centring planets is complicated and expensive.

To overcome these difficulties, a recently developed "twin-planetary" epicyclic gear has two planet gears mounted on eccentric pins on diametrically opposite sides of one carrier. Each pin is connected with a lever terminating in a gear segment, and the two segments are in mesh at the centre of the gear train. If one planet takes a higher load than the other, the levers are automatically turned slightly in opposite directions, and the planet gears are displaced radially by means of the eccentric pins, so as to restore equal load distribution. Owing to the high lever/eccentricity ratio, the load on the gear segments is very small and the width of the segments need only be $\frac{1}{15}$th of the gear width. If the eccentric pins are supported in ball bearings, friction is negligible, so that the loading can be balanced to about 98% independently of manufacturing accuracy. The radial change in axial distance between the meshing gears is within permissible limits, e.g., 0·001 in. for profile errors of up to 0·08 in. The design is dynamically balanced and, because of load equalization, is subject to pure couples only, so that the bearings can be made simple and small and the sun gear need be supported on one side only. Profile and pitch errors are counterbalanced to a certain extent by the eccentric adjustment, as is evident from the extraordinarily quiet running of the gear. The gear, which is robust and inexpensive, can be manufactured by conventional methods and transmits double the power of a single planetary gear of equal dimensions.

From *Österreichische Ingenieur Zeitschrift*, Austria.
March 1960, pp. 103–105.

● *MATERIALS WITH BOTH FERROELECTRIC AND FERRIMAGNETIC PROPERTIES*

Ceramics with magnetic properties have long been known but, until now, none has exhibited both ferroelectric and ferrimagnetic properties at the same time. Thus, ferroelectrics normally have a high dielectric permittivity and very low magnetic permeability, while ferrimagnetics have a high magnetic permeability and very low dielectric permittivity. It is now reported, however, that a series of materials with a single-phase crystalline structure, simultaneously exhibiting ferroelectric and ferrimagnetic properties, has been discovered. As ferroelectricity and ferrimagnetism seem to be mutually dependent in these materials, which basically comprise a barium niobate containing any one of several rare earths plus iron oxide, they should find application in new electronic components where a coupling between dielectric and magnetic effects is desirable, or where a magnetic material with a high dielectric constant would be useful.

Samples of the new material are made in accordance with normal ceramics-laboratory procedures, i.e., mixing the constituents, pressing them into pellets, and firing until they sinter. Some of these compositions have been made with the rare earths neodymium, samarium, europium, or gadolinium, with varying amounts of iron oxide, and all have shown both ferroelectric and ferrimagnetic properties in a single-phase crystalline form. The presence of the rare earth and the iron seems to be necessary for the material to show both properties simultaneously, the kind of rare earth used having a considerable effect on the Curie points of the compositions.

From *Technical News Bulletin, National Bureau of Standards*, U.S.A.
February 1960, pp. 29–30.

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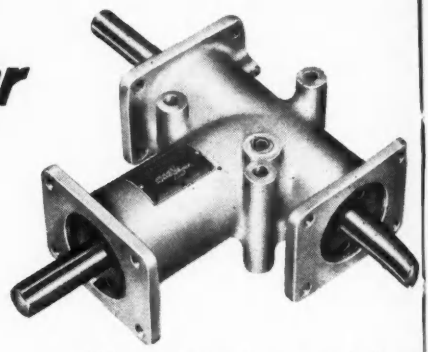

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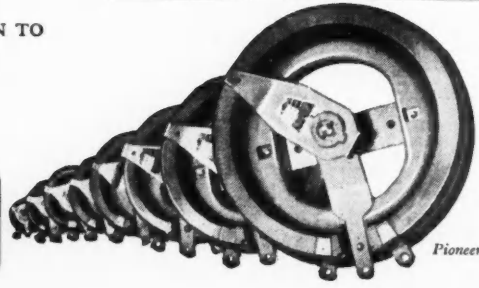
5	2.24	3.16	3.86	4.77	5.48	6.71	7.75	10.0
7.5	1.82	2.56	3.16	3.65	4.47	5.48	6.32	8.17
10	1.58	2.24	2.74	3.16	3.88	4.74	5.48	7.07
15	1.29	1.83	2.24	2.58	3.16	3.87	4.47	5.78
25	1.00	1.41	1.73	2.00	2.45	3.00	3.46	4.47
50	.707	1.00	1.23	1.41	1.73	2.12	2.45	3.16
75	.578	.818	1.00	1.15	1.41	1.73	2.00	2.58
100	.500	.707	.866	1.00	1.23	1.50	1.73	2.23
150	.408	.575	.707	.818	1.00	1.22	1.41	1.82
200	.354	.500	.612	.707	.866	1.06	1.22	1.58
350	.268	.378	.463	.535	.655	.803	.926	1.19
500	.224	.316	.388	.447	.548	.671	.775	1.00
1,000	.158	.224	.274	.316	.388	.474	.548	0.708
1,500	.129	.183	.224	.258	.316	.387	.447	.578
2,500	.100	.141	.173	.200	.245	.300	.346	.448
5,000	—	.100	.123	.141	.173	.213	.245	.315
7,500	—	.081	.100	.115	.141	.173	.200	.258
10,000	—	—	—	.110	.125	—	.173	.224
15,000	—	—	—	—	—	—	—	.163



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• *ULTRASONIC WELDING OF DISSIMILAR-METAL COMBINATIONS*

Ultrasonic welding techniques are being effectively used for joining dissimilar metals which are difficult to join by more conventional techniques. Such junctions are generally free from the interdiffusion, intermetallic compounds, and brittleness often associated with fusion bonding. Potential applications of ultrasonic welding are found in structural, electrical, and electronic fields, bonds of structural integrity having been produced in bimetal combinations of many of the high-temperature refractory metals and alloys, such as titanium, zirconium, molybdenum, and the precipitation-hardening stainless steels. Electrical connections, such as the attachment of leads to coils, or contacts to a variety of configurations, are readily produced with combinations of silver, copper, aluminium, and other materials. Good-quality junctions of excellent conductivity are reproducibly achieved, even through certain insulating coatings.

Another interesting application is the bonding of gold contacts to gold-plated beryllium springs. Ultrasonic welding may also be employed for the joining of various metals to an iron-nickel-cobalt alloy frequently used where glass-to-metal seals are required. The process is of interest also for certain types of electrical connections, such as the joining of stranded aluminium wires to copper terminals. Potential applications of this technique also exist in the manufacture of electronic tubes, ultrasonic welding of the components eliminating the contamination which is such a serious problem in obtaining tubes of high reliability. Furthermore, it would permit the use of materials such as titanium which, at present, cannot be used because of the difficulty in welding these materials to dissimilar metals.

From *Welding Journal*, U.S.A., February 1960, pp. 131–138.

• *TRANSISTORIZED ULTRASONIC POWER GENERATOR*

The increased use of ultrasonic energy in industrial applications has created a larger demand for ultrasonic-frequency power supplies, most of which are constructed with thermionic valves as the conversion device. However, power supplies embodying transistors operated as high-current switches can be made higher in power-conversion efficiency and more compact for the same power rating.

A recent paper reviews a number of circuits which have been utilized in the generation of ultrasonic-frequency power by means of transistors, and states that ultrasonic power generators have been constructed with ratings of 50 W to 1 kW. The frequency of the germanium transistors used is a function of temperature, supply voltage, and load, the frequency variation from transistorized power generators being 1% per 10°F temperature variation and 1% for a supply-voltage variation of 10%, with a frequency variation of 0·02% from no-load to full-load.

A 1-kW unit, 20 in. in width, 9 in. in height, and 15 in. in depth, has been constructed. This unit weighs less than 50 lb and has a d.c.-to-a.c. power-conversion efficiency of about 85%, whereas, by comparison, a generator of the same power rating using thermionic valves may be three times as heavy and be only about half as efficient. At the present time, the cost of transistor units is higher than that of thermionic units, but this situation is expected to improve when higher-power transistors become available. Laboratory samples of silicon transistors rated at 300 V and 20 A are already available.

From *Communications and Electronics*, U.S.A., January 1960, pp. 1062–1064.

• *SHIPS WITH RUBBER COATINGS TO REDUCE TURBULENCE*

The question why porpoises can swim so swiftly with so little apparent effort has led to the development of specially designed rubber coatings which effectively reduce the turbulence normally created when an object moves through water. In fact, one such coating is claimed to reduce drag by about 50% on underwater measuring devices, although greater reductions are theoretically possible. Wide application of these coatings is foreseen for pleasure craft which plane on water, although larger surface vessels, such as freighters, tankers, and passenger liners, are less likely to derive immediate benefits, because they generate large bow waves.

Many compounds and designs have been tried, the most practical development so far being a thin layer of rubber supported by a multitude of tiny rubber pillars. Interconnecting channels between the pillars contain a freely flowing viscous liquid. The channels face the surface of the hull, the outside, or water side, of the coating being smooth. The channels give the coating flexibility, and the liquid provides the necessary damping to suppress potential turbulence.

From *Mechanical Engineering*, U.S.A., March 1960, pp. 84–85.

Readers desiring further information on any developments reported in THE BLUE PAGES are invited to write to the Editor. Copies of the full specifications of any British patents mentioned, which are published by courtesy of H.M. Stationery Office, should be obtained from the Patent Office, 25 Southampton Buildings, Chancery Lane, London, W.C.2. Price 3s. 6d. each.

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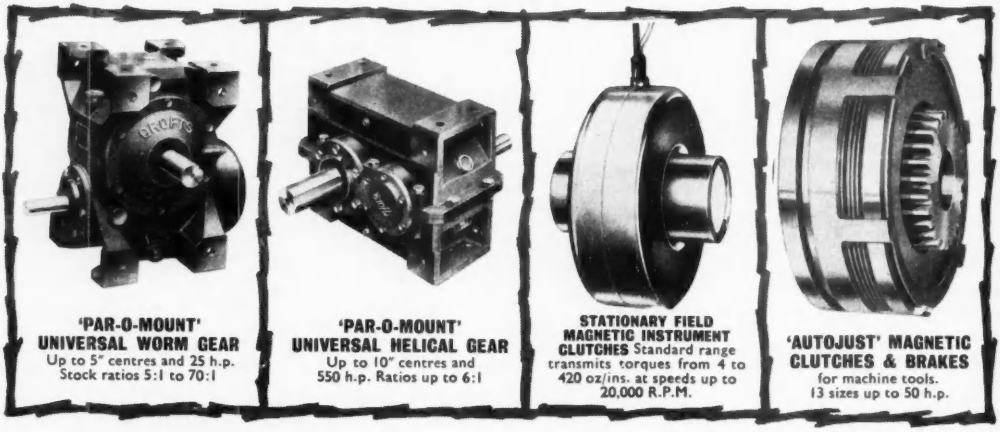

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VOL. XXI No. 4 APRIL, 1960

Flexible Printed Circuits and their Design

By V. DAHLGREN

From *Machine Design*, U.S.A.,
Vol. 32, No. 6, March 17, 1960,
pp. 146–159, 22 illustrations

OFFERING the advantage of efficient packaging into a three-dimensional arrangement which can be small, light, and relatively economical, flexible printed circuits basically comprise etched circuits composed of copper conductors encapsulated in any one of a wide variety of flat and flexible insulating plastics. The bond between the conductors and the insulation is virtually indestructible, so much so that the insulation cannot be peeled off without first destroying the unit. As a result, the bond provides an effective barrier against the penetration of moisture or gases.

Essentially, then, flexible printed wiring is a marriage of conventional wire circuits and printed-circuit boards, using a variety of insulating materials of thin flexible plastic, with only the terminations exposed. The flat conductors can take any configuration to close tolerances, as required by the circuit layout, so that the circuit can be bent, twisted, coiled, preformed, and fitted flat into corners, while the feeder arms can take off from the main cable in any direction.

The projected use of flexible printed wiring does not affect any design considerations until the early model or prototype stage is reached, when such factors as package form, size, weight, construction, cost, and environment pose a large number of problems that can be solved with this new circuitry.

To design the flexible printed circuit, a rough sketch of the wiring layout is the first step. When perfected to the point of accurate positioning and detailed dimensions, this sketch evolves into master art-work for reproduction. During the in-between stages, the sketch is refined to a wiring-circuit mock-up, which can be made of cardboard, paper, or transparent acetate, a transparent mock-up being especially useful for planning multi-layer circuits. A paper mock-up can be folded, cut out, formed to fit corners, and cut to conform to components in exactly the same way that the completed flexible printed circuit can be manipulated.

To achieve maximum efficiency and economy in printed-circuit production, the conductor pattern should be arranged, if possible, to obviate the need for cross-overs. Also, all terminations, i.e., uninsulated portions, of conductors should appear on one side only. Flexible printed circuits manufactured with cross-overs as multilayers and with terminations on both sides are more complicated to manufacture and are therefore more costly. At this early stage, they should be eliminated, if possible. In certain circumstances, the dictates of high circuit density, small size, light weight, or simplified assembly require cross-overs, and these requirements can all be met. It should, however, always be borne in mind that the surface of a flexible printed circuit is not confined to a single plane, but may be in many planes, perpendicular or stacked.

By using common printed-circuit techniques, the design-drafting group can prepare final art-work and, in many cases, photographic negatives for reproduction. When the circuit pattern is complete, the electrical and mechanical parameters of the flexible printed cable or harness can be specified for design-drafting.

The materials used in flexible printed wiring can be divided into three categories, i.e., (1) base or insulating materials, (2) supporting, i.e., stiffening or rigidizing, materials, if required, and (3) conducting materials. With regard to base or insulating materials, temperature range, moisture-absorption characteristics, chemical inertness, flexing strength, tensile strength, electric strength, dielectric constant, ageing effects, and cost are all important factors influencing the selection of base material. Similarly, careful consideration should be given to the effects of using a supporting material. Supporting or reinforcing materials can be bonded to flexible printed wiring to provide dimensional stability, rigidity, mechanical support, better resistance to abrasion, or shielding. Glass cloth, metal mesh, sheet metal, or many types of thermosetting plastic boards are materials which can be used.

Conductors

Rolled copper foil of more than 99% purity is normally used for conductors and shields, although other grades can be employed. Conductor widths and thicknesses are determined chiefly by the required current-carrying ability. Because a selection of copper thicknesses is available, this ability may also represent a compromise between flexibility and minimum line width—the thicker the copper, the smaller the width for a given current-carrying capacity.

The width-to-thickness ratio of conductors should be 6 or more, and conductors should have a minimum width and spacing of 0·025 in. By observing these arbitrary limits, the designer can automatically eliminate many production difficulties. When these minimum figures cannot be adhered to, conductor widths as small as 0·010 in. are possible, and even narrower lines can be held for sub-miniature applications. Careful art-work is of key importance when working to these fine line dimensions, and special problems might still arise.

Wire size, or conductor width and thickness, may affect the permissible temperature rise. Other factors which should be considered are type and thicknesses of insulation, supporting materials, number of layers,

number of conductors per cable, and environments. In general, the printed conductor shows a better temperature-rise characteristic than its equivalent wire size, because the flatness of the printed conductor gives a better ratio of exposed surface to volume for heat dissipation.

The current I_2 required for a given temperature rise at some high ambient temperature can be expressed as

$$I_2 = I_1\sqrt{R_1/R_2} \quad .. \quad .. \quad .. \quad ..(1)$$

where I_1 is the amperage required for the same temperature rise at a lower ambient temperature, R_1 is the resistance [ohms/ft] of the copper at the lower ambient temperature, and R_2 is the resistance at the higher ambient temperature.

Fig. 1 shows the variation of resistance temperature coefficient α with temperature for pure annealed copper. If the resistance R_1 at any temperature T_1 is known, the resistance R_2 at any other temperature T_2 can be determined as

$$R_2 = R_1[1 + \alpha(T_2 - T_1)] \quad .. \quad .. \quad .. \quad (2)$$

where α is the resistance temperature coefficient of the copper at the known temperature T_1, as derived from Fig. 1.

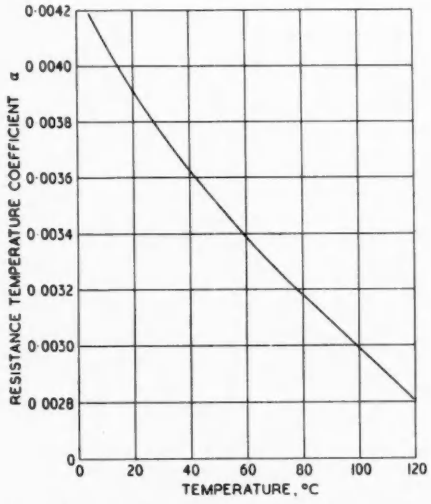


Fig. 1. Resistance temperature coefficient of pure annealed copper as a function of temperature.

Flash-over or arcing between exposed conductors is a function of conductor spacing, exact values depending on humidity, atmospheric pressure, and other factors. Fig. 2 shows typical curves of flash-over voltage for exposed copper in air at sea-level, using both alternating and direct current.

The shape of conductor terminations should be designed to accommodate the form of attachment used. Usually, terminations consist of exposed copper areas or "pads", perforated to admit a connector pin or component lead and placed at any point along the length of a conductor. Cable design should always provide for adequate spacing between terminal and adjacent conductors. Round terminating pads are most commonly used, but close spacing may necessitate using elongated, narrower shapes. Adequate area should be provided to ensure that

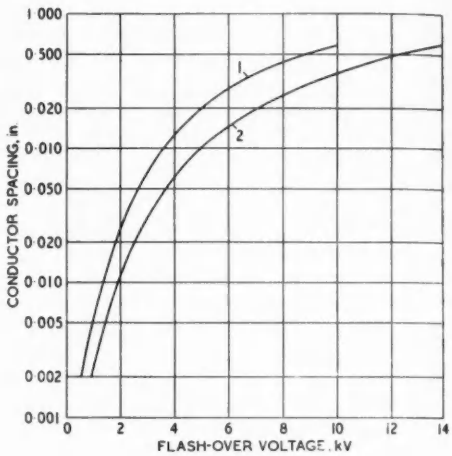


Fig. 2. Influence of conductor spacing on flash-over voltage for exposed copper in air, in the case of (1) 60-cps alternating current, and (2) direct current.

the pad is entirely clear of insulation, thus providing enough copper for a good solder fillet.

Multi-Layer Construction

When it is not practical to design the circuit with all conductors on a single surface, i.e., with no cross-overs, a multi-layer construction of flexible printed circuit can be used. Also, when exceptionally high wiring density, shorter routing of interconnections, smaller circuit area, shielding, or stiffening of the circuit is needed or desired, this construction can be employed.

Layers are insulated from each other, and may be either laminated together or left separate and joined through connectors at the termination. Important work simplification in assembly results from using one part, instead of two, three, or four separate pieces. The circuit may require interconnection between layers.

The design of this type of circuit is the result of a number of trial layouts aimed at finding the most direct, efficient, and economical compromise. Two precautions should be observed, i.e., (1) conductors on each layer must be routed, and terminations and components located, so that no terminations are superimposed on another layer; and (2) if interconnections are to be made between layers, art-work must be prepared for both layers with points of interconnection in register, this being easily accomplished with a transparent plastic overlay.

Various types of shielding can be designed to provide flexibility. Lattice shielding, with the lattice structure running across the conductors at an angle of 45 deg., is effective and permits sharp bending of the shielded cable. A solid shield can be used where electrical conditions demand it, and where minimum flexing or bend radius is required.

Dimensional Tolerances and Art-Work

Art-work should be planned with the same considerations that apply to designing hardboard printed circuits made with thermosetting plastics. If the tolerances can be maintained, a 360-deg. solder fillet at connections can be practically guaranteed.

Generally, tolerances of $\pm 0{\cdot}005$ inch per inch of width can be held. For larger sections, tolerances of $\pm \frac{1}{16}$ inch

per foot are practical. Pieces running 1 foot or longer should be laid out with a tolerance of $+\frac{1}{8}$ inch per foot, and it is good practice to design to the " long side " of these dimensions. All solder pads should be designed as large as possible, and yet be consistent with circuit characteristics dictating available space.

A variety of methods will assure accurate alignment of flexible circuits with connectors and components. These methods include (1) slitting the ends of cable lengthwise, to allow enough side-to-side " play " for positioning termination pads; (2) adding a negligible amount of cable length to overcome any critical dimensions in the longitudinal direction. When holes are matched to pins, the extra length is absorbed in an indiscernible catenary or ripple; and (3) drilling or punching eccentrically either standard or oversize termination pads to match connector pins.

In preparing art-work, a drawing material having the dimensional stability of plastic-impregnated glass cloth should be used. All lines in the art-work must appear dense and opaque to the camera, and have sharply defined edges. Sharp-line ink drawings are satisfactory, but any voids left in the ink drawing appear in the finished circuit; ragged edges on the conductors detract from appearance and might show up under high-voltage tests, with misleading results.

For small areas, the use of black pressure-sensitive

(*Concluded on page 129*)

The Causes and Prevention of Spring Failures

By E. BRUDER

From *Der Maschinenschaden*, Germany,
Vol. 33, No. 1/2, February 1960,
pp. 13–18, 19 illustrations

THE life of springs in service varies considerably, and failures can generally be attributed to sudden fractures usually associated with excessive hardness of the material, to fatigue fractures, and to softening, i.e., reduced elasticity. A fatigue fracture under alternating loading occurs when the operating stress exceeds the dynamic fatigue strength of a spring made from a specified material and suitably heat-treated. Fatigue fractures usually originate at positions of high stress concentrations, i.e., at spots where there are surface defects such as scale or annealing marks, slag inclusions, drawing and rolling marks, hardness cracks, etc., or where the surface has been damaged during manufacture, assembly, or in service.

Improper heat treatment, such as incorrect tempering, which in some cases causes soft spots by excessive surface decarburization, can also lead to spring failures; the decarburized areas then mainly consist of ferrite, which has a comparatively low fatigue strength and therefore favours the occurrence of fatigue cracks. In particular, silicon spring steels tend to decarburize during forging, rolling, and drawing operations. However, excessively hardened zones and the use of unsuitable material can also bring about spring failures.

The softening of springs is mainly due to conditions in which the dynamic yield strength of the material is exceeded. The permanent set resulting from a deterioration of the elastic properties is frequently due to improper tempering, to intermittent overloads, and particularly to the falling off of the yield point of the material at high operating temperatures.

If a spring is chosen with too many turns, it may become coil-bound under the operating load and will then behave like a rigid connection, causing damage to other parts of the machine in which it is fitted.

Examples of Failure of Helical Springs

In a cardboard factory, the pressing device of a paper-cutting machine failed suddenly because the springs bearing on the pressing beam had broken in several places. The pressing arrangement in this instance comprised three individual springs in series, each with a length of 570 mm, a coil diameter of 112 mm, and a wire diameter of 22 mm, made from rolled (but not drawn) bar steel and subsequently tempered. The outer region of the fractured areas showed a fine-grain, grey, and velvet-like structure, while the centre showed a fracture which was similar in appearance to a fracture in wood. This fractured structure is normal for the hardened spring steel considered and is characteristic of a sudden torsional failure. The fracture originated at two positions, another crack in this

Fig. 1. Photomicrograph of a polished section through the cracked area of a spring from a paper-cutting machine. (×65)

area indicating a manufacturing defect. A photomicrograph of the polished specimen (Fig. 1) shows in this area a wide, irregular crack in the neighbourhood of irregularities and inclusions, clearly indicating a defect which must have occurred during the hot-rolling of the round bar. A finer crack *d*, visible in the lower part of the photograph, probably only occurred later, during coiling of the spring or during tempering.

Fig. 2. Fracture of a helical spring from the screening box of a vibratory separator.

Another example of damage concerns a helical spring, with a coil diameter of 170 mm and a wire diameter of 30 mm, which broke into three parts and was the cause of damage in the screening box of a vibratory separator. Its coils showed marks on the inner and outer sides, which were due to the roll gap and which extended over the entire length of the wire, but, as the surface of the spring had been provided with a black coating, these marks were not noticeable during assembly. One of these marks is illustrated in Fig. 2 and shows a sudden fracture originating at a ridge with an initial crack D_1 which led to a typical fatigue failure. The crushing of the material at point *a* probably occurred only after fracture. Surface treatments for increased durability, such as sand-blasting, etc., had not been applied to this spring.

In an automatic sprayer, two compression springs, with a coil diameter of 115 mm and a wire diameter of 28 mm, showed fractures after only 70,000 operating cycles, whereas the original springs had withstood 2,000,000 cycles. The springs had untreated surfaces,

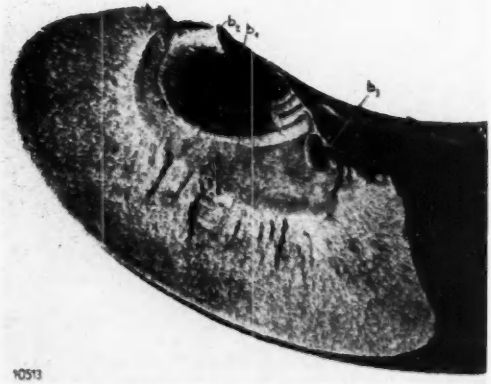


Fig. 3. Failure of a helical spring from an automatic spraying machine.

and were still covered with scale from annealing and rolling. They also showed longitudinal grooves b_1 and b_2 (Fig. 3), evidently due to the rolling process, from which a fatigue failure developed. A second, smaller fatigue fracture had its origin at a surface defect b_3, which can also be identified as initiating in a groove. The material was a normal silicon spring steel, the strength of which was within the usual limits and which seemed perfectly suitable for the purpose of this application.

Metallographic investigation revealed a wide crack, with several branches at its lower end, in which deformations and dislocations were apparent, indicating a manufacturing defect due to the crushing action (rolling defect). In the subsequent hardening of the spring, hardness cracks had developed from this position. Moreover, some small overlaps were found, as well as a soft skin which was caused during manufacture or heat treatment. These surface defects were the sole causes of the fracture. The suggestions made before the investigation, to the effect that the springs should have been subsequently stress-relieved or should have been made from a different material, were therefore not relevant.

The governor spring of a high-speed steam engine suddenly broke into several pieces, with considerable destruction of associated components. This spring was a tension spring with a wire diameter of 22 mm, and examination of one of the fractured surfaces (Fig. 4) clearly showed that the fracture had developed from the inner side of the spring and had been initiated by narrow, step-

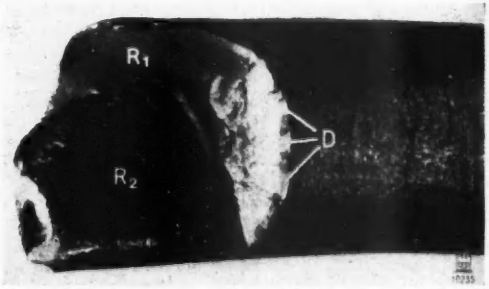


Fig. 4. Fracture in a governor spring from a steam engine.

like fatigue cracks *D*. These initial cracks combined into a common front, with a fracture area of somewhat coarser structure. This long-term fracture was then followed by sudden ruptures at R_1 and R_2. Many other cracks were also found on the inner side of the coil, and some showed similar step-like patterns, and further hairline fatigue cracks were observed in the suddenly fractured areas. The spring had a finely peened surface, which indicated that it had been sand-blasted or shot-blasted, and this was subsequently confirmed by metallographic investigations. Possibly, the peening of the surface had not been continued long enough to be fully effective.

A polished specimen from a longitudinal section, however, showed that, without exception, the cracks had developed perpendicular to the surface into the full body of the cross-section and in all likelihood had not been caused by material defects or surface damage. It was considered most probable, therefore, that this spring, which was made of a tempered chrome-vanadium steel, had been continuously subjected to high stresses, which exceeded the fatigue strength of the material on the inner surface of the wire, where in helical springs the highest

stresses of the cross-section can be expected to occur, these stresses producing the fatigue cracks which caused the fracture.

A high-speed cutting machine suddenly ceased operation, and it was found that one of the four parts of its spring, which was wound from a round bar material, 22 mm in thickness, had broken in several places. One of the fractured portions showed a crescent-shaped fatigue fracture which, as clearly indicated in Fig. 5, originated from a damaged surface where some contact pressure was apparently exerted during operation.

The springs of fuel-injection pumps in diesel engines are particularly highly stressed elements. When a rough-running engine of 220 hp was investigated, it was found that several fuel-pump springs had failed. The fractures had developed partly from the inner side and partly from the seating, and had been caused not by flaws in the material but by dents or pressure marks on the wire surface. This is another indication of the extreme sensitivity of springs to surface damage, which considerably reduces their life.

Fig. 5. Pressing-beam spring, showing surface damage which subsequently led to fatigue failure.

The danger of using springs with an unsuitable number of turns is exemplified by a series of failures in a rotary compressor, in which, in a period of six months, damage had occurred alternately in the high-pressure and low-pressure stages. In this machine, in order to enable the rotor to expand inside the casing in accordance with the operating temperature, while remaining in its correct centre position, the bearings were supported on 32 helical springs which had the same dimensions for the high-pressure and the low-pressure stages. These interchangeable springs were removed each time damage occurred and were subsequently replaced at random in any of the positions provided for them. The fact that one of these springs had too many turns was not at first noticed; as a result, this spring was fitted once in the high-pressure stage and subsequently in the low-pressure stage, and each time was the cause of damage, since it acted as an incompressible element.

Fracture of a Torsion-Bar

Corrosion pitting was the cause of fracture of a round-section torsion-bar, which was subjected to purely torsional loading. A small, dark-coloured area of the fatigue fracture and the pitted region of the initial crack are clearly visible in Fig. 6.

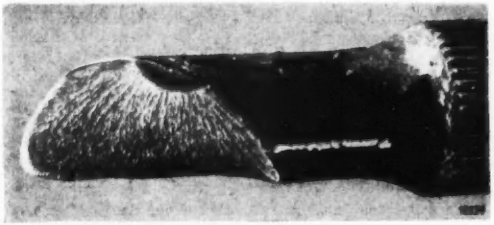


Fig. 6. Fracture of a torsion bar, showing corrosion marks.

The motor vehicle from which this spring was taken had been frequently driven over muddy ground and had not been adequately maintained. As a result, rust had gradually developed under the protective coating and, in the pitted area caused by corrosion, a small fatigue crack had been formed and was the cause of the fracture.

Examples of Failures of Leaf Springs

In railway rolling stock, modern designs of leaf springs using bosses and corresponding indentations, coupled with improved manufacturing techniques, do not generally suffer from damaged areas produced during manufacture, with the possibility of subsequently giving rise to fatigue failures. However, in the reconditioning of leaf springs for railway rolling stock, hidden cracks, which might develop into complete fractures of the leaves, have sometimes been revealed. Shot-blasting of leaf springs is not as yet common practice in railway workshops, owing to its cost, although it would certainly bring about the removal of rust, as well as thorough cleaning of the surfaces. In the case of these leaf springs, particular importance must be attached to spring hardness, which should conform strictly to specifications, recommended Brinell-hardness values being between 350 and 420 kg/mm².

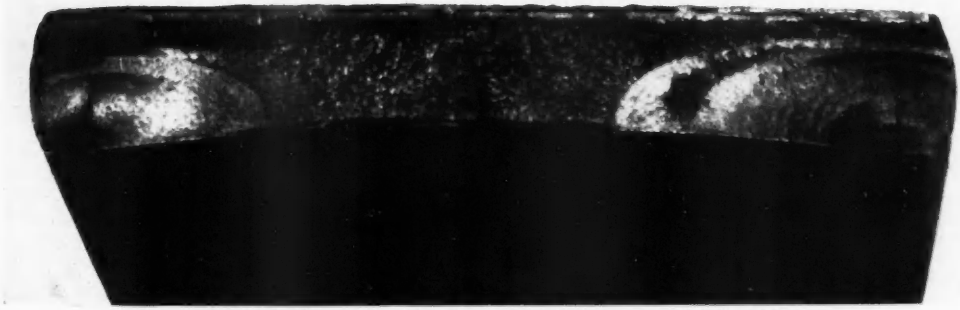


Fig. 7. Leaf spring, showing edges damaged by rubbing, resulting in fatigue failure.

Fatigue failures of leaf springs also occur in motor vehicles. A fractured lamination from a spring of an older type of passenger vehicle showed fine initial cracks at both ends of the cross-section, caused by rubbing (Fig. 7). These appeared first as short step-like cracks perpendicular to the leaf surface, and from these positions two fatigue fractures developed and ultimately caused failure of the entire cross-section.

Service Failures of Miniature Springs

In the miniature springs used in the watchmaking industry, damage to the edges and to other parts of the surface can occur either during manufacture or as a result of corrosion, resulting in fatigue failures of the springs in service. An incipient spring fracture originating at a rusty position can act as a stress raiser, while failure can also occur if the material has a sharp kink or bend at which contact pressure can be concentrated (Fig. 8).

In electrical instruments, spring failures can also be caused by surface damage due to high-tension sparking, as illustrated in Fig. 9, the burnt area again acting as a stress raiser and causing failure.

Damage to edges, as can occur while the spring steel for miniature springs is being fed to a stamping machine can also subsequently lead to failures.

Prevention of Spring Failures in Practice

The materials selected for highly stressed springs require careful checking to ensure that they fulfil requirements as regards quality and strength, and particularly to determine their resistance to dynamic loads. As regards the manufactured product, heat treatment must be correctly applied and supervised, and damage to the surface must be scrupulously avoided, to ensure that the springs will have the required service life.

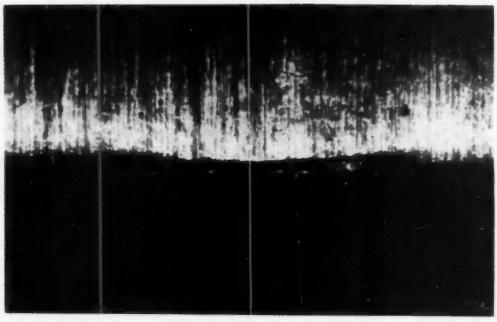


Fig. 8. Incipient crack in a small spring, caused by a sharp bend. (×15)

Grinding and polishing of the material after drawing serve to eliminate notches and other stress-raisers, but the manufacturing costs increase correspondingly, so that, for economic reasons, these operations are often not practicable. The best solution usually is to provide springs with a sufficiently high safety margin to reduce risk of failure, though it is true that spring failures can never be eliminated completely. An important point to remember is that machines using springs should be designed in such a way that the failure of a comparatively cheap element like a spring cannot cause costly damage to any other part, and merely requires replacement of the fractured spring element.

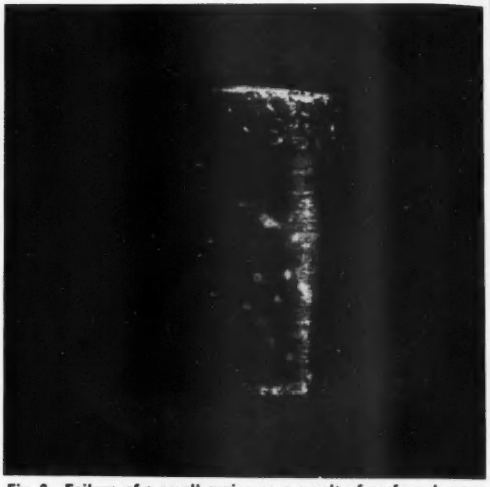


Fig. 9. Failure of a small spring as a result of surface damage caused by high-tension sparking. (×10)

Shot-peening of the surface is probably nowadays the most rational method of improving spring life, particularly since it not only removes the outer skin with scale and other defects, but also enables, in some cases, the decarburized surface layers to be removed. The surface, however, should be shot-blasted only to a sufficient extent to confer the required fatigue-resisting properties. Tests have shown that there is less damage to the surface with low shot-blasting pressures and small sizes of peening material. However, it is advisable to operate initially at a fairly high blasting pressure, so as to remove rapidly the decarburized layers and to obtain favourable compressive stress conditions in the material, a lower blasting pressure then being used to smooth out any small marks on the surface.

Improvements in spring life can also be obtained by pickling and varnishing, by plating with cadmium, zinc, tin, or chromium, or by nitriding, particularly if corrosion is expected under service conditions.

With regard to the selection of spring steels, helical springs should have a Brinell hardness between 390 and 500 kg/mm², an ultimate tensile strength between 135 and 170 kg/mm², and an elongation between 5 and 15%. Leaf springs should have a Brinell hardness between 310 and 450 kg/mm² (350 to 420 kg/mm² for railway rolling stock), an ultimate tensile strength between 110 and 160 kg/mm², and an elongation between 5 and 15%. In all cases, the lower values given are preferable.

In the case of high-quality torsion bars and helical springs with ground or sand-blasted surfaces, Brinell hardness should be between 490 and 530 kg/mm², the ultimate tensile strength between 160 and 185 kg/mm², and elongation between 4 and 8%, though the values of elongation can, if desired, be higher.

The structure of all springs should be sorbitic, and their permissible service stresses should, as a general rule, not be higher than from 50 to 80% of the fatigue strength. It should also be noted that premature failure of springs made from materials of extra-high quality has sometimes been reported and that their replacement by ordinary springs, which have a lower notch sensitivity, has occasionally resulted in an improvement in such cases. However, in this connection, it is not possible to generalize.

Hard-Facing of Metals with "Powder-Tape" Electrodes

By O. A. Baksi, E. F. Belousov, G. P.Klekovkin, V. M. Solovskoy, and T. V. Sumina

From *Svarochnoye Proizvodstvo*, Russia,
No. 3, March 1960,
pp. 30–33, 8 illustrations

In order to improve the efficient production of wear-resistant surfaces on machine components, a new type of " powder-tape " electrode developed in Russia can be used in submerged-arc automatic and semi-automatic metal-deposition processes. The electrode can also be used for manual hard-facing.

As can be seen from Fig. 1, a hard-alloy powder (3) is enclosed between two steel strips, the lower corrugated strip (1) being provided with small compartments for the powder, and the covering strip (2) enclosing the powder in the assembly. The special construction of this electrode permits uniform distribution of the powder in all directions, confers on the electrode greater longitudinal flexibility combined with sufficient lateral rigidity, and prevents spillage of the powder from the electrode. Also, a wide variation in the chemical composition and other characteristics of the deposited metal can be achieved, while the process is claimed to ensure high productivity and good-quality hard-wearing surfaces at low cost.

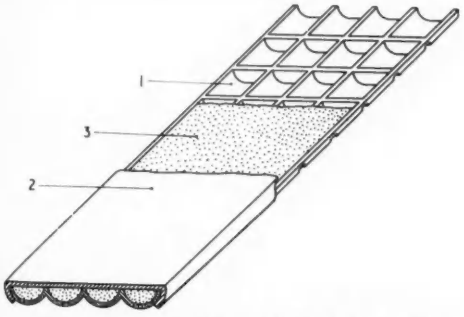


Fig. 1. Construction of the new powder-tape electrode.

The powder-tape electrode can be manufactured separately, or continuously during the actual hard-facing operation on special equipment attached to the welding machine. An example of such an arrangement is shown in Fig. 2, in which two coiled strips (1) are directed through sets of guiding and shaping rollers, the lower strip passing through rollers (3) and (4), which form the strip into its cellular corrugated shape, and the upper strip through rollers (2), which produce the cover. The corrugated strip collects powder from a hopper (7), the amount of powder being controlled by a shutter (9). The covering strip passes through a slot (8) in the hopper (7), the two strips being joined by rollers (5), and the assembled electrode entering the electrode holder (6). In operation, an arc is struck between the electrode and the parent metal, the generated heat melting the tip of the electrode and initiating metal deposition under the shield of a granular flux supplied to a funnel-shaped container via a hose (10).

The performance of the new powder-tape electrode has been tested with automatic, semi-automatic, and manual equipment, and the quality of deposits in each case analysed, and the optimum conditions for efficient metal deposition determined. For automatic operation, special equipment was constructed on the lines of the arrangement shown in Fig. 2, the entire unit being mounted on the saddle of a lathe. The guiding and shaping rollers were driven by a 0·6-kW asynchronous motor through a worm-gear reduction unit and sets of bevel gears. Current to the electrode was supplied from two welding transformers in parallel.

For all experiments, the powder-tape electrode was made up of two cold-rolled low-carbon steel strips, containing 0·05 to 0·12% carbon, 0·25 to 0·5% manganese, 0·3% silicon, up to 0·15% chromium, and up to 0·3% nickel, using as a filling a special alloy powder containing 10% carbon, 16% manganese, 1·5% silicon, and 18% chromium. The thickness of the strips was 0·6 to 0·8 mm, and the width of the finished tape about 45 mm.

During tests with the automatic process it was found that the arc completely melts the constituents of the powder-tape electrode, fusing them into one drop and thereby increasing the stability of the arc and preventing spraying out of the alloy powder from the electrode prior to metal deposition. For this automatic process, optimum results were achieved with both alternating or direct current of 1250 to 1350 A and 35 to 40 V, with a speed of deposition of 22 m/hr. Under these conditions, the coefficient of deposition was found to be 16·5 gm/A-hr, and the electrode loss about 2 to 3%.

In hard-facing processes, great importance attaches to the hardness and wear resistance of metal deposits; with a view to finding the most suitable composition of the electrode materials, special tests were therefore carried out in which the proportion of the hard-alloy powder constituent was varied between 30 and 45% of the total weight of the electrode, and the effects of this variation on the composition of the deposit were determined. The results of these tests are plotted in Fig. 3, from which it can be seen that, while the percentage of silicon in the deposit remains fairly constant after an initial slight increase, the carbon, chromium, and man-

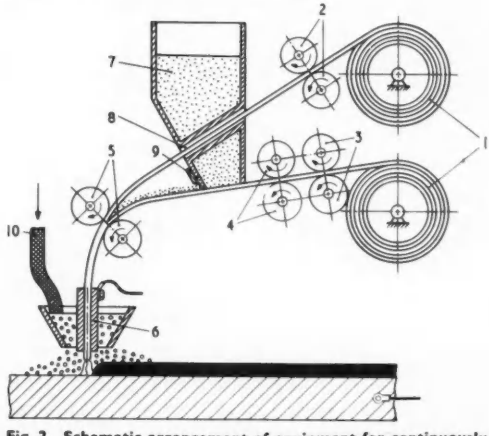


Fig. 2. Schematic arrangement of equipment for continuously producing the powder-tape electrode.

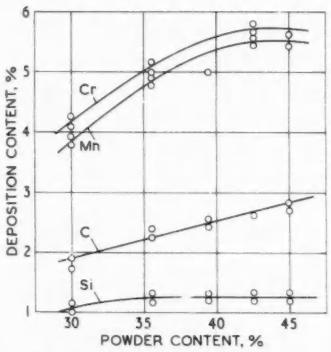


Fig. 3. (Variations in Cr, Mn, C, and Si contents of the deposits formed, as functions of the powder content of the electrode.

ganese contents increase substantially with an increasing percentage of powder in the electrode. Obviously, the increase in the hardness of the deposit follows a similar pattern, increasing with increasing carbon, manganese, and chromium contents. With a recommended powder content of 40%, the hardness of the metal deposits was about 46 to 52 R_C.

A detailed examination of the microstructure of the deposits obtained by the automatic process indicates that the deposits have a clearly defined austenitic base with a Vickers microhardness of 450 to 500, this base being covered by a troostite and carbide phase with Vickers microhardnesses of 520 to 560 and 1017 to 1020 respectively. Generally, the deposits are of good quality, free from pores and cavities, and fusion of the parent metal does not exceed 1 to 2 mm in depth.

The new electrode was also tried out in a semi-automatic process, in which a layer of flux, 5 to 8 mm in thickness, was first deposited on the surface of the parent metal, the flux being covered by a prefabricated powder-tape electrode which, in turn, was covered by another layer of flux, with a copper plate on top. The free end of this horizontally arranged electrode was clamped in an electrode holder, and the arc struck at the other end, gradually traversing the whole length of electrode and workpiece and effecting metal deposition. For this process, both direct and alternating current can be used, the best results being achieved with a current of 400 to 500 A and a speed of deposition of 7 to 9 m/hr. Under these conditions, the coefficient of deposition is 16 to 18 gm/A-hr and the electrode loss 2 to 3%. The metal deposits obtained are of high quality, free from pores and slag inclusions, and fusion of the parent metal is insignificant (0·5 to 0·75 mm in depth). The microstructure of the deposit is similar to that obtained with the automatic process, and the hardness of the deposit is about 48 to 50 R_C.

Manual hard-facing experiments were also carried out with a prefabricated electrode, which, however, had to be provided with a protective coating to prevent contamination of the deposit by nitrogen or oxygen. The coated electrodes were cut into short pieces, each 450 mm in length, and the process was carried out both with direct and alternating current, the optimum conditions being a current of 350 to 400 A at 17 to 20 V and a speed of deposition of 7·5 to 9 m/hr. The coefficient of deposition in this case did not exceed 7·5 to 8 gm/A-hr.

A Method of Measuring the Resistivity of Protective Coatings on Metals

By L. Rivola

From *La Metallurgia Italiana*, Italy,
Vol 7, No. 1, January 1960,
pp. 15–18, 7 illustrations

The purpose of protective paint coatings on metallic structures is to provide a continuous barrier which will isolate the metal from physical contact with the ambient medium and protect it from possible galvanic corrosion. In addition to a high electrical resistance, the coating should be stable and should have extremely low water-absorption properties.

As coatings with a sacrificial pigment (such as those with a metallic zinc base) are not here considered, it can be said that the high ohmic resistance of coatings is one of their basic characteristics. From the electrochemical point of view, the coating eliminates the effects of the voltages of local corrosion cells by interposing a high resistance between the galvanic elements and the electrolytic medium.

Many experimental investigations have established the importance of electrical characteristics for the assessment of coatings. Thus, the values of conductivity, capacitance, and polarization potential are definite functions of the quantity of water absorbed, while the variation of impedance with frequency depends mainly on the porosity and the adhesive strength of the coating to the metal base.

Porosity, in particular, results in the formation of small anodic zones at the pores, surrounded by fairly large cathodic areas. The pore, therefore, is a corrosion centre, since it allows direct contact between the aggressive medium and the metal base and also provides a path to the cathodic areas surrounding it. The output of the cells thus formed is closely associated with the resistivity of the coating, which limits the short-circuit current, so that the value of resistivity is indicative of the protective properties of a coating.

In measuring resistivity, however, it will nevertheless be necessary to take account of the polarization impedance, since the potential difference between the metal and the medium, owing to the passage of current, includes a reactive component which is determined by the capacitive characteristics of the coating.

Experimental Investigation

In the measurement of resistivity of coatings, the following considerations must always be borne in mind:

(1) Current density must be kept to a minimum value, to avoid polarization phenomena which are not reproducible and which have irreversible effects.
(2) The electrical resistivity of coatings is generally extremely high, ruling out the possibility of using a bridge method of measurement, which is insufficiently accurate for such high values of resistance.
(3) The necessity for isolating the reactive component from the ohmic component requires the use of a measuring current of suitable waveform.

In this investigation, it was therefore considered necessary to employ a method which would give voltage and current measurements and which would enable very low currents to be indicated. Pulsing techniques were found suitable for this purpose, square-wave pulses, with steep flanks on both sides and an interruption period equal to the pulse duration being generated.

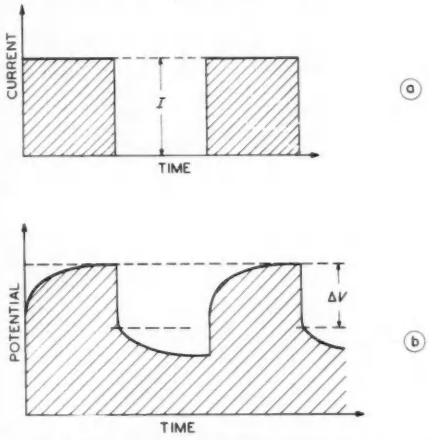


Fig. 1. Typical oscillograms of (a) current, and (b) potential waveforms obtained with square-wave pulses.

The ohmic and the reactive components of the coated metal surface, immersed in an electrolyte, together with an insoluble anode, were determined from the waveform of a voltage curve, and the waveform of the measuring pulse was obtained as a current curve, both curves being displayed simultaneously on an oscilloscope screen. Fig. 1 shows typical oscillograms of current and voltage, in which the amplitude and waveform of the excitation pulse are obtained by indicating the potential drop across the terminals of a calibrated resistance placed in series with the test cell. The voltage waveform (Fig. 1b), taken directly from the two electrodes of the cell, has two main features, i.e. (1) sudden jumps, corresponding to interruptions or applications of current, and due solely to the ohmic component, and (2) rising or decreasing curve portions, caused by the non-instantaneous charging and discharging of the polarization reactances. Electrical resistivity can be determined directly from the instantaneous drop in potential $\triangle V$ represented by the height of the pulse, giving the resistance R as $\triangle V/I$.

In view of the high electrical resistivity of coatings, the measuring cell was so designed as to provide fairly large electrode surfaces, and, for convenience, a cell of cylindrical shape was used, with an inside diameter of 10 cm, made from polyvinyl chloride. The anode, of fairly large size, was made in the form of a stainless-steel probe and inserted through the cylindrical wall in the transverse plane of symmetry of the cell. The cell was

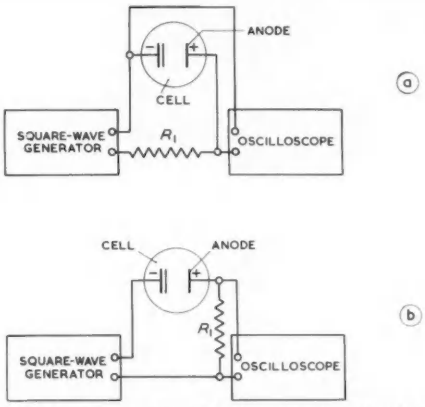


Fig. 2. Basic arrangements used (a) for measuring potential, and (b) for measuring current.

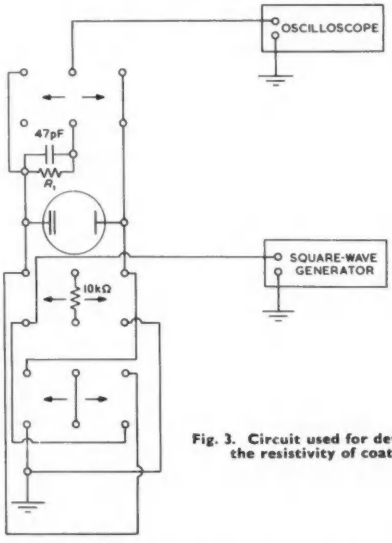


Fig. 3. Circuit used for determining the resistivity of coatings.

closed at its ends by two coated metal plates of circular shape (12 cm in diameter), which could be held tightly against the edges of the cylinder by means of four externally arranged tie-rods and suitable fittings. Artificial sea-water was used as the electrolyte in the cylinder, the ratio of the exposed surface areas to the volume of the electrolyte being 260·6 cm^2/cc.

The basic measuring arrangements are illustrated in Fig. 2, in which the oscilloscope terminals are connected in parallel with the cell for the measurement of potential (Fig. 2a), and in parallel with the resistance R_1 for the measurement of current (Fig. 2b). The oscilloscope used had an input impedance of 2 megohms and a maximum sensitivity of 10 mV/cm; the square-wave generator had an output impedance of 75 ohms, with a maximum attenuation of 80 dB.

The complete electrical circuit, shown in Fig. 3, includes a multipole switch which allows measurements to be made of either current or voltage, with the specimens always acting as cathodes, and providing for the earthing of the square-wave generator and the oscilloscope. Since

Flexible Metallic Couplings with Dynamic Links

By M. F. BALZHI and G. D. ESIN

From *Vestnik Mashinostroyeniya*, Russia,
No. 1, January 1960,
pp. 31–36, 7 illustrations

MANY current designs of flexible shaft couplings using springs, rubber pads, or other resilient materials suffer from a number of defects, including comparatively ow flexibility. high weight, high moment of inertia, and low tolerances to misalignments, as well as lack of reliability and limited service life.

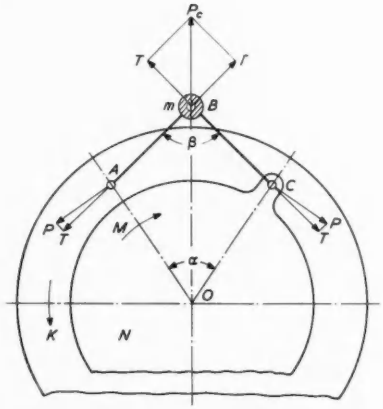


Fig. 1 Principle of operation of a non-reversible flexible coupling with dynamic links.

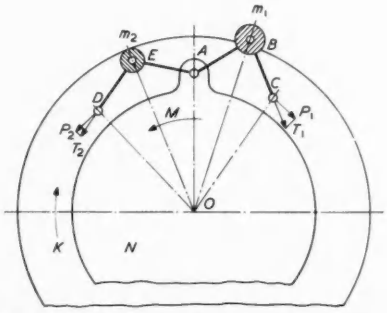


Fig. 2. Principle of operation of a reversible flexible coupling with dynamic links.

In order to overcome these difficulties, a new type of flexible metallic coupling has been developed in Russia, in which use is made of dynamic links, as shown in Fig. 1, which refers to a non-reversible coupling of this type. The main feature of the coupling is a hinged link *ABC*, the link pair being connected at the point *A* to the driving disc *K*, and at the point *C* to the driven disc *N*. During operation, as a result of a centrifugal force P_c, the relative positions of points *A* and *C* are displaced through an angle β around the pivot-point *B*, with a relative displacement α of the driving and driven discs. The forces acting on the link can be resolved into components *T*, which in turn give rise to tangential components *P*, ensuring the actual transmission of the torque *M*.

The magnitude of torque *M* [kgcm] can be obtained from the relation.

$$M = \frac{mrz\omega^2}{2} \times \frac{\left(r\cos\frac{\alpha}{2} + l\sqrt{1-\lambda^2\sin^2\frac{\alpha}{2}}\right)\sin\frac{\alpha}{2}}{l\sqrt{1-\lambda^2\sin^2\frac{\alpha}{2}}}$$

where *m* is the mass of the linkage [kg-sec²/cm], *r* is the hinge radius, i.e., $AO = CO$ in Fig. 1, [cm], *l* is the length of each link [cm], $\lambda = r/l$, *z* is the number of link pairs, and ω is the angular velocity.

In order to make the coupling reversible, counter-links *AED* are fitted, as shown in Fig. 2, the transmitted torque *M* being equal to the difference between the torque M_1 of the main linkage *ABC* of mass m_1 and the torque M_2 of the counter-linkage *AED* of mass m_2. Under no-load conditions, $M_1 = M_2$.

In these couplings, the magnitude of transmitted torque *M* is proportional to the square of angular velocity, and their flexibility varies over the operating range, increasing with high relative angles of displacement α. In general, their flexibility is high throughout the entire operating range and they have a very high damping capacity, completely isolating vibration of the driving system from the driven member. It is true, however, that, at very low speeds, a shortcoming of the coupling appears to be that of reduced flexibility, particularly during starting.

The simplest form of link arrangement is shown in Fig. 3a, in which plate-type links (1) are held in place by

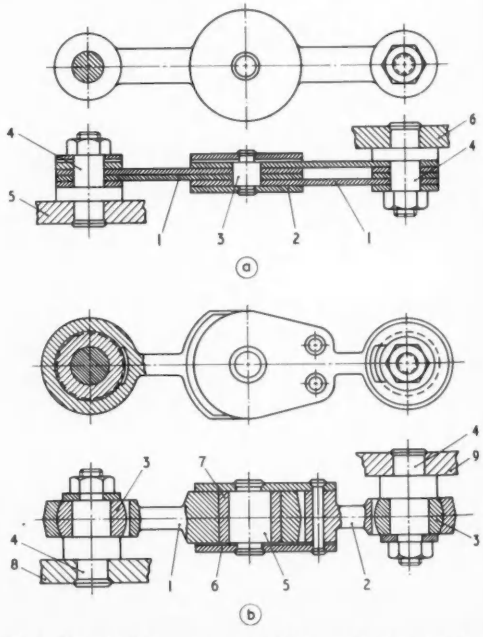


Fig. 3. Typical link arrangements of the new flexible coupling.

plates (2) and pivot around the hinge (3), being joined by pivots (4) to the driving member (5) and the driven member (6). This design is of simple construction and is basically intended for the transmission of relatively low torques and where the two shafts are in fair alignment.

Where it is desired to transmit higher torques (200 to 300 kgm) and where parallel misalignment (up to 3 mm or more) and a considerable degree of angular misalignment must be accommodated, the design shown in Fig. 3b, is recommended, in which solid-type links (1) and (2) are held by plates (6) and pivot around the hinge (5) in a bush (7). The ends of the links are free to move around pivots (4) in spherical bushes (3), connected to the driving member (8) and driven member (9).

The Heat Treatment of Electroless Nickel Coatings

By K. T. Ziehlke, W. S. Dritt, and C. H. Mahoney

From *Metal Progress*, U.S.A., Vol. 77, No. 2, February 1960, pp. 84–87, 6 illustrations

Electroless nickel, a chemically deposited alloy of nickel and phosphorus, has a corrosion resistance in most environments equivalent to that of wrought nickel. The plating, which is amorphous in the as-deposited condition, is non-porous, even in very thin layers, and will cover intricate surfaces uniformly. The as-deposited plate consists of laminations parallel to the base metal, hardness being 500 to 600 DPH (Rockwell C-50 to 55).

Although it is known that the nickel-phosphorus coatings are heat-treatable to high hardness, no work has been reported which relates various heat-treatment cycles with hardness. For this reason, the investigations described in this article have been made with a view to studying the response of electroless nickel coatings to heat treatment over a wide range of times and temperatures.

Combinations of hardness and ductility best suited to a specific job are readily obtained by proper selection of the heat-treatment cycle. The effect of phosphorus has also been evaluated over the range encountered in commercial electroless nickel deposits. Samples included in the investigation were plated on mild steel and also on S.A.E. 52100 steel (containing 0·95–1·10% carbon, 0·25–0·45% manganese, 1·30–1·60% chromium, 0·20–0·35% silicon, and up to 0·025% each of phosphorus and sulphur). The samples were cut from larger discs to give a plated area of about 0·5 sq in., and phosphorus contents were first determined by wet chemical analysis and subsequently, as a result of the development of special techniques, by direct spectrography.

Changes in Microstructure

No changes in microstructure were observed in samples heat-treated below 750°F, although hardness increased from the as-deposited level to a peak of about 1000 DPH. Above 750°F, precipitation and agglomeration could be detected. Agglomeration becomes pronounced with increasing temperature and time of heat treatment and is more rapid in coatings with a low phosphorus content.

Photomicrographs have indicated clearly the change in structure which occurs when coatings containing 8·5% phosphorus are heated at various temperatures for 1 hr. Thus, the laminated structure of the as-deposited plate is still prominent after heat-treating at 750°F to obtain maximum hardening, whereas at 950°F the laminations are much less prominent and a precipitate appears which starts to agglomerate at 1110°F, hardness dropping to 725 DPH. Clearly resolvable particles are present in the microstructure at a temperature of 1380°F.

A summary of the heat-treatment response of a coating containing 8·5% phosphorus is given in Fig. 1, covering times from 3 min to 2 hr in air in a thermostatically controlled furnace. The very-short-time response of a series of samples containing 8·7% phosphorus was studied by heat treatment in a salt bath, and these data are summarized in Fig. 2.

Mechanism of Hardening

Electroless nickel is amorphous in the as-plated condition. Such a deposit might be expected to be structurally unstable and responsive to heat treatment, even at low temperatures. The approach to peak hardness in the first stage of heat treatment can be attributed to the establishment of an interim crystal lattice in the initially amorphous deposit. Only a small amount of atom movement is required to form this lattice from the amorphous structure, since no diffusion is required. At high temperatures, the transformation is rapid. The transformation is exothermic, indicating an ordered structure.

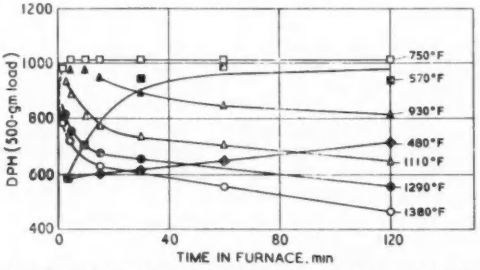


Fig. 1. The effects of heat treatment in air in a thermostatically controlled furnace on the hardness of an electroless nickel plate containing 8·5% phosphorus.

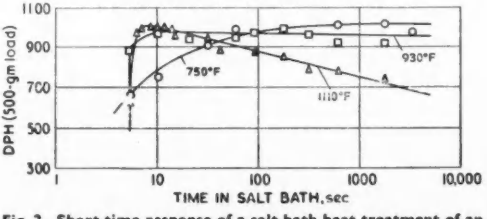


Fig. 2. Short-time response of a salt-bath heat treatment of an electroless nickel plate containing 8·7% phosphorus.

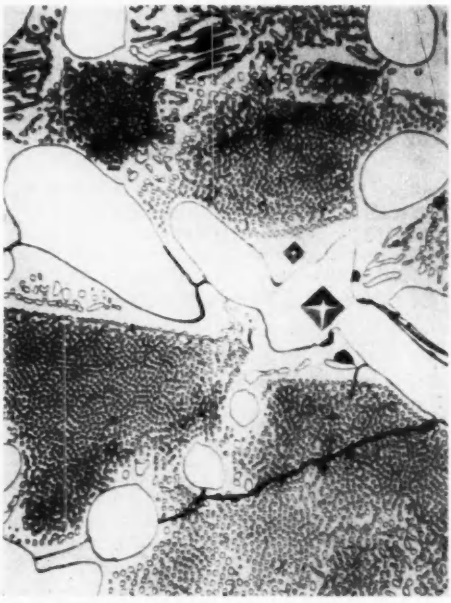


Fig. 3. Microstructure of a cast nickel alloy containing 9% phosphorus. Etched in sodium cyanide/ammonium peroxide. (× 450)

The high hardness of the newly established lattice arrangement is probably due to distortion caused by the non-equilibrium locations of the atoms of nickel and phosphorus. As heat treatment continues, atoms diffuse to more stable locations and hardness drops. Fig. 3 shows the microstructure of a cast nickel alloy containing 9% phosphorus. The continuous phase, i.e., the Ni_3P matrix, is hard (about 760 DPH with a 25-gm indenting load) and brittle—a characteristic of intermetallic compounds. The dendritic phase (α-nickel) has a hardness of 190 DPH, but this discontinuous phase, in both cast and plated samples, is harder than pure nickel (75 DPH).

The diffuse halo pattern observed in X-ray reflection studies of the amorphous deposit gradually sharpens with low-temperature heat treatment as the interim lattice is formed. Nickel lines can be positively identified in the halo background after 15 min at 570°F. The X-ray identification of Ni_3P in this structure is more difficult, because of a large number of other lines (probably higher phosphides). Lines identified as Ni_3P intensify in samples heat-treated at 750°F, and the interfering lines become fewer and weaker in intensity with advancing heat treatment. Above 750°F, the halo pattern disappears rapidly. Evidence of grain growth in both nickel and Ni_3P can be seen in samples heat-treated for an hour at 1110°F.

Effects of Phosphorus

Phosphorus does not seem to play an important part in the early response of electroless nickel to heat treatment. For example, when samples with three different phosphorus contents (7·2, 8·7, and 10·3%) are heated at 1110°F, all of them reach the same hardness peak (1000 DPH). After the peak has been reached, phosphorus has a pronounced effect. Thus, a 2-hr treatment at 1110°F reduced the hardness of a sample containing 10·3% phosphorus from 100 to 790 DPH. In the same time, the 7·2%-phosphorus plate softened to 580 DPH.

Softening occurring with prolonged heat treatment depends on co-precipitation and agglomeration of nickel and nickel phosphide from the pseudo-stable interim lattice, and the hardness of the coatings appears to be a function of the amount of hard Ni_3P present.

One of the drawbacks of electroless nickel coatings is the weakness inherent in the laminated structure. That the laminations can be eliminated by heat treatment and that they are more readily eliminated in coatings of lower phosphorus content, because of more rapid agglomeration of the constituent phases, are advantages of heat treatment.

Ductility

Early in the test programme it was difficult to obtain crack-free hardness indentations in the hard coatings. It was found that the indenting load required to crack the coatings is related to the hardness and phosphorus content, and this correlation suggested that the load required to cause cracking could be taken as a measure of the ductility of the samples. For example, Fig. 4 shows ductility, as measured by the minimum indenter load required to cause cracking, as a function of phosphorus content, and indicates that, at a given hardness level, ductility decreases as phosphorus content increases. The degree of cracking under constant indenting load also changes with phosphorus content, cracking being found to be most severe in the case of samples with the highest phosphorus content. Thus, at equivalent hardness levels, nickel coatings of low phosphorus content are more resistant to chipping and shattering than those of high phosphorus content.

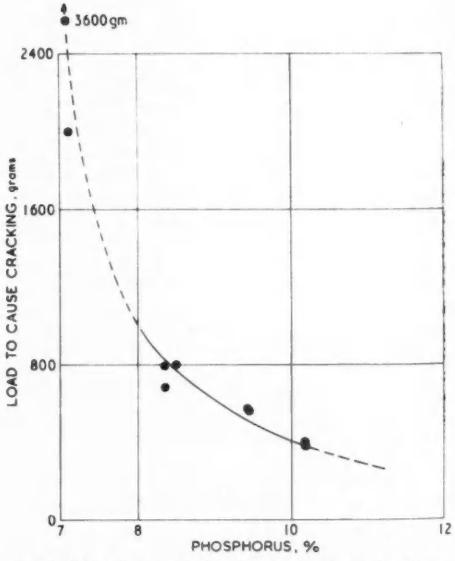


Fig. 4. The influence of phosphorus content on ductility.

Work is continuing on coatings with phosphorus contents below 7%, with a view to obtaining high hardness without sacrificing ductility. Studies are also being conducted to determine the effects of variations in phosphorus content and heat treatment on the corrosion resistance of the coatings.

The Behaviour of Liquid Dielectrics under Corona Discharge

By F. HELD and H. BÜCHLER

From *Schweizer Archiv*, Switzerland,
Vol. 26, No. 1, January 1960,
pp. 13–17, 8 illustrations

MOST electrical insulation employed in general engineering practice is structurally heterogeneous, i.e., it consists of a combination of different insulating materials, such as mica and a binder, as used in conventional alternators, or paper and oil in high-voltage cables. If an alternating voltage is applied to such a heterogeneous dielectric, three basic classes of electric losses occur, i.e., (1) ohmic losses determined by the internal and surface resistances of the insulation, (2) relaxation losses determined by the dielectric polarization, and (3) ionization losses due to glow and corona discharges, if the dielectric contains voids and the field strength is sufficiently high to cause discharges to occur. This latter class of losses is of particular importance in respect of high-voltage applications. The general trend towards compressing more capacity into ever smaller space has necessarily led to the use of higher voltages and field stresses and has given added importance to the question of the corona resistance of liquid and solid insulating materials.

As regards liquid dielectrics, especially in high-voltage cables, the problems posed by ionization losses have long been known. Micro-discharges in the gas contained in small cavities in the insulation produce energy carriers—mainly electrons and ions—which collide with the molecules at the interface between gas and solid, producing excited molecules or radicals which, being reactive particles, enter into secondary reactions with the ionized gas, depending on the nature of the gas. The phenomena taking place in such a cavity or gas bubble are very complex, since several transformations occur simultaneously, such as the dissociation of oil molecules into compounds of lower molecular weight, the formation of products of higher molecular weight by polymerization of radicals, and hydration and dehydration processes, all of which, being irreversible, give rise to changes in the dielectric properties of the insulation (Fig. 1).

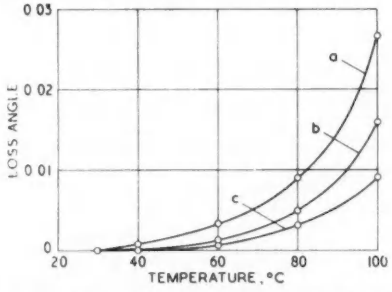


Fig. 1. } **Variation in dielectric losses of an insulating oil as a result of corona discharge.**
(a) After 13 hr corona discharge.
(b) After 6½ hr corona discharge.
(c) Initial condition.

The deterioration of the insulation is mainly due to two processes, i.e., (1) the dissociation of gases, predominantly hydrogen, causing an enlargement of the gas-filled cavities and hence an intensification of corona discharge, and (2) the formation of compounds which may be both polar and of high molecular weight and which either form true or colloidal solutions in oil, thus increasing the dielectric losses, or else insoluble products which impede the free flow of the oil.

Depending on the chemical composition of a hydrocarbon type of insulating oil, the gas formation resulting from corona discharge may differ from case to case. For this reason, the cable industry has developed specific testing methods to investigate what has been called the gas behaviour of insulating oils. These methods, including those devised by Pirelli, Wörner, and others, are essentially based on the use of a principle in which the field strength between the internal electrode and an external electrode is so chosen that a corona discharge occurs in the air space above the oil. The strongly inhomogeneous field causes mixing of the oil at the interface, providing favourable conditions for the reaction to take place.

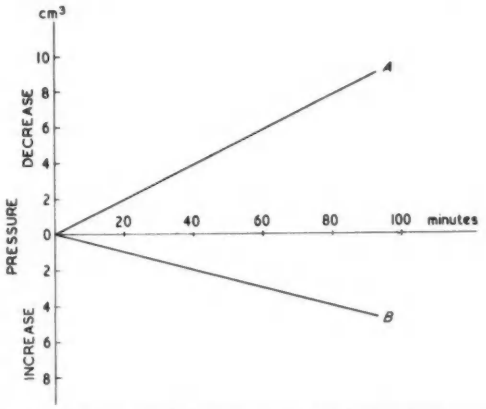


Fig. 2. Manometer displacement as a function of time, i.e., gassing factor *S*, for two oils in a hydrogen atmosphere, showing (*A*) an oil with a positive gassing factor, and (*B*) an oil with a negative gassing factor.

If the reaction takes place in a hydrogen atmosphere at a given temperature and field strength, two cases can be distinguished, as shown in Fig. 2. The gas behaviour is defined by the so-called " gassing factor *S* " (a measure of change in pressure with time), and is expressed by $S = 100\ V/t$, where V is the manometer displacement [cm³] and t is the time [min], using dibutylphthalate as the manometric fluid.

An oil, such as oil *A* in Fig. 2, which releases the hydrogen so as to cause the pressure in the manometer to increase, is described as having a positive gassing factor and is considered unsuitable for use as an insulating oil for high-voltage installations and especially high-voltage cables, as distinct from oil *B* in Fig. 2, which has a negative gassing factor.

When air is used, instead of hydrogen, the results are more complex. Thus, oils with positive and negative

gassing factors initially show gas absorption (a pressure drop in the manometer), but subsequently, after reaching a well-defined inversion point, begin to release gas. The initial falling off of pressure is attributed to the formation of ozonides, and the subsequent pressure rise to the dissociation of these ozonides and the release of hydrogen. The difference in the behaviour of oils with positive and negative gassing factors is therefore not noticeable until after a certain interval of time, as shown in Fig. 3.

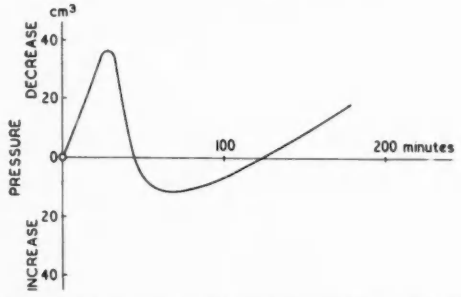


Fig. 3. Behaviour of an oil with a negative gassing factor in air.

Since, in practice, air occlusions constitute the most frequent cause of corona discharges, gas behaviour is of particular interest when air is used, especially as regards the reaction products formed. An investigation into the gas behaviour of insulating oils in respect of different atmospheres was carried out at the Institute for Engineering Physics in Zürich and, as a part of this investigation, a series of experiments was carried out on different substances.

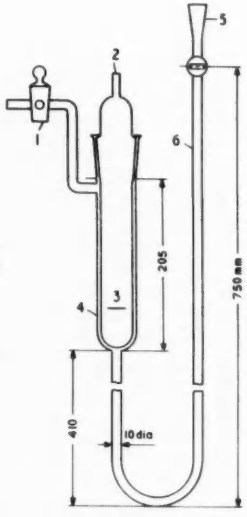


Fig. 4. Corona-discharge apparatus for test substances.
(1) Stopcock for drawing off gas.
(2) Inner electrode.
(3) Reference mark.
(4) Outer electrode.
(5) Cock for introduction o test substances.
(6) Manometer.

In these experiments, special apparatus, with concentric glass electrodes, as developed by Wörner, but in a slightly modified form, was used (Fig. 4). The inner electrode (2) is filled with a concentrated solution of sodium chloride, and the entire apparatus is placed in a thermostatically controlled bath of saturated sodium chloride solution, forming the outer electrode (4). An operating voltage of 16 kV results in field strengths in the gas space of 53 kV/cm at the inner electrode and 45 kV/cm at the outer electrode, and in the oil of 48 kV/cm at the inner electrode and 44 kV/cm at the outer electrode.

From the calibrated initial volume, the density of the experimental medium, the atmospheric pressure before and after the experiment, and the measured pressure difference, the change in volume or displacement [cm³] can be calculated.

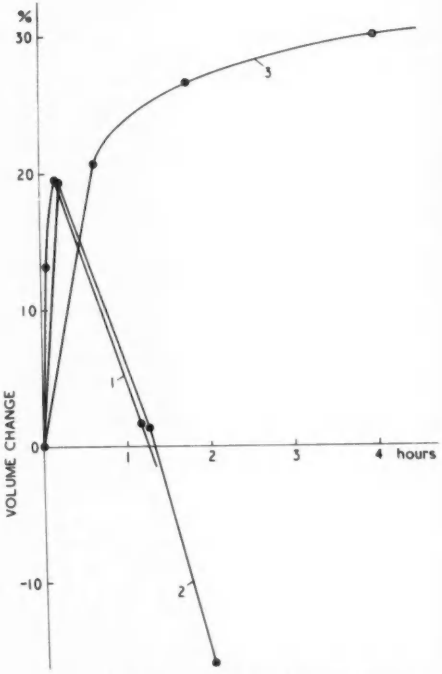


Fig. 5. Gas behaviour of test substances in air.
(1) *n*-heptane; (2) cyclohexane; (3) benzene.

As mineral insulating oils contain, depending on their origin and blending, three basic types of hydrocarbons, i.e., aliphatic, alicyclic or naphthenic, and aromatic compounds, simple hydrocarbons were chosen as test substances, these being normal heptane, cyclohexane, and benzene, which in many ways are similar to the three basic types.

To test the reproducibility of gas behaviour with the apparatus used, tests were carried out with cyclohexane, the duration of the individual corona discharges being 70 min, and it was found that there was adequate agreement, particularly with respect to the gassing factor *S*. The gas behaviour of the three test substances in air is shown in Fig. 5. In order to eliminate the influence of nitrogen, analogous experiments were carried out with cyclohexane and benzene in an atmosphere consisting of 80% argon and 20% oxygen, the corresponding gas behaviour being shown in Fig. 6. Analysis of the gas was effected with special apparatus which has the advantage of permitting relatively small volumes to be analysed without appreciable loss of accuracy and makes it possible to perform two analyses for every measuring point.

In the tests on cyclohexane, both in air and in the argon/oxygen atmosphere, it was noted that, after some

time, colourless films of solid wax-like substances were deposited on the walls of the discharge space. No discoloration of the cyclohexane in the cell was observed. In general, there was considerable similarity between normal heptane and cyclohexane as regards their gas behaviour and the composition of the gas.

In the case of benzene in air, small brown droplets formed on the walls of the discharge space, later turning into a brownish-black solid resinous film, while the benzene in the cell became of a brownish colour. In the argon/oxygen atmosphere, yellow wax-like films were formed in the discharge space, though to a lesser extent than in air, while the benzene in the cell became slightly discoloured, turning light-yellow.

The pattern of the pressure drop (gas absorption) was very similar for all three test substances, and the gas analysis showed that the pressure drop was caused by oxygen absorption in the liquid dielectric, i.e., by oxidation. The formation of ozonides through ozone has already previously been assumed by Wörner on the basis of investigations into the gas behaviour of oils, the aromatic components of the oil reacting to form ozonides. The gassing factor of an oil with a tendency to gas absorption is considered to be the result of four simultaneously occurring reactions, as shown in Fig. 7, the reactions of the individual processes being (1) formation of ozone (pressure drop), (2) release of hydrogen (pressure increase), (3) formation and dissociation of ozonides (pressure drop followed by pressure rise), and (4) absorption of hydrogen (pressure drop).

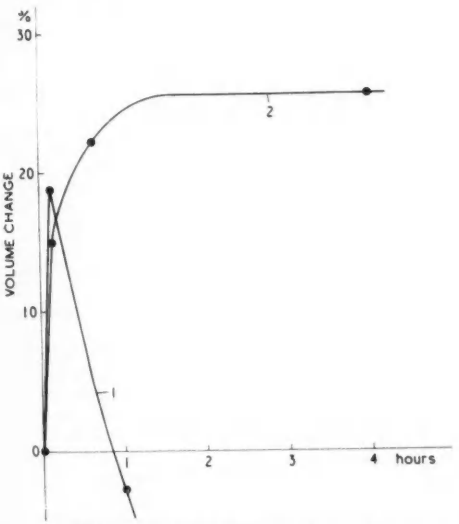


Fig. 6. Gas behaviour of cyclohexane and benzene in an atmosphere of 80% argon and 20% oxygen.
(1) Cyclohexane. (2) Benzene.

The experiments on the test substances indicate, however, a somewhat different mechanism of reactions. The initially rapid pressure drop is predominantly due in the case of normal heptane, cyclohexane, and benzene to oxygen absorption. Since this occurs in an analogous manner for all three substances and, furthermore, the oxygen content of the gas space decreases continuously, oxidation by way of ozone/ozonide formation and dissociation into oxygen and carbonyl compounds, as previously assumed, is improbable. The addition of oxygen presumably occurs, as in the case of reactions with ionizing radiation, at activated points of the hydrocarbon molecule, or directly on radicals, the unstable peroxides dissociating into hydroxyl and carbonyl compounds.

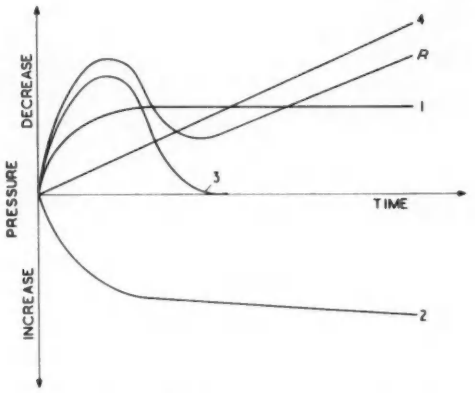


Fig. 7. Analysis of the gas behaviour in air of an oil with gas-absorbing tendencies.
(1) Formation of ozone.
(2) Release of hydrogen.
(3) Formation and dissociation of ozonides.
(4) Absorption of hydrogen.
(*R*) Gas-behaviour curve.

The behaviour of benzene under corona discharge is largely identical with the behaviour of aromatic hydrocarbons under ionizing radiation, the absorbed energy being distributed over the whole molecule. Although the energy of dissociation of a hydrogen atom (4·5 eV) is smaller than the ionizing energy (9 eV), ionization preferentially occurs, owing to the distribution of the energy over all hydrocarbon compounds. Both in air and in an argon/oxygen atmosphere, the release of water is very small. It is known from the chemistry of radiation that, in condensing systems, exchanges of charges and excitation take place between molecules. In this way, an aromatic hydrocarbon protects very much more sensitive components of the same solution from dissociation (hydrogen release) without itself being consumed. The aromatic system is not only able to take on the directly absorbed radiation energy, but also the energies of other substances present in the same system. The fact that insulating oils containing a certain proportion of aromatic compounds show no or only a very small tendency to release gases when subject to corona discharges must also be attributed to this specific protective action.

The pressure drop in air is also conditioned by the chemical reaction of the nitrogen, presumably via compounds of nitrogen and oxygen. The decrease of argon noted in the gas space can be attributed to physical absorption in the liquid phase during gas absorption, since argon is again liberated during the gas release phase.

The strong discoloration, especially in the case of benzene in air, and the increase noted in electrical conductivity and in dielectric losses point to a formation of strongly polar compounds. Also, in this case, the conditions are qualitatively similar to those obtaining when insulating oils are subjected to ionizing radiation in the presence of air.

The conclusions derived from this investigation can be summarized as follows:—

(1) In the gas behaviour of hydrocarbons in air, the

initial pressure decrease is caused by oxygen absorption, i.e., oxidation, and to a lesser extent to chemical reactions with nitrogen. As soon as all oxygen has been taken up from the gas space, a pressure increase, i.e., gas release, takes place in the case of aliphatic and alicyclic compounds, the gas released consisting mainly of hydrogen and to some extent of hydrocarbons of low molecular weight. In the case of aromatic hydrocarbon compounds, however, no generation of hydrogen has been observed. The behaviour of aromatic hydrocarbons under corona discharge corresponds qualitatively with their behaviour under ionizing radiation.

(2) In all cases, two types of reaction products are formed in the gas space, i.e., polar products (oxygen- and nitrogen-containing compounds) and unsaturated hydrocarbons, the latter being formed by hydrogen dissociation with aliphatic and alicyclic hydrocarbons. The compounds formed are either soluble in the dielectric concerned, depending on their molecular weight and composition, or they are segregated preferentially at locations of high field strength in the form of wax-like, usually discoloured, products which are partly insoluble in organic solvents. Dissolved polar compounds have a deleterious effect on dielectric properties.

(3) Based on these experiments, it appears that, with hydrocarbon-type insulating oils, a positive gassing factor is possible only if a definite quantity of aromatic hydrocarbons is present. The stabilizing effect of these aromatic hydrocarbons is most favourable when their concentration in the gas space is a maximum, i.e., when their vapour pressure is higher than that of the other hydrocarbons present in the insulating oil.

Core Models for Obtaining Electrical Data on Insulation Bushings

By R. D. ALVORD

From *Power Apparatus and Systems* (*A.I.E.E.*), U.S.A.,
No. 45, December 1959,
pp. 1029–1032, 10 illustrations

MOST modern bushings made in the U.S.A. use oil-impregnated paper as the main insulation, and the voltage between line and earth is graded by means of conducting elements called equalizers, which are placed at predetermined intervals between line and earth, as shown schematically in Fig. 1.

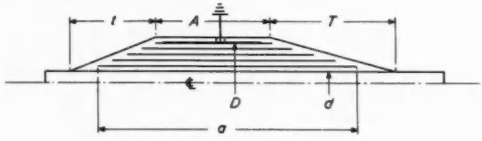


Fig. 1. Structure of a bushing core.

Various papers and equalizer patterns must be evaluated in order to obtain the best bushing design, but the testing of full-size bushings is not economically feasible, because of the large number of samples required for complete evaluation. Consequently, for such an evaluation programme, use has been made of " corettes ", which are models of the cores of full-size bushings, in which the top- and bottom- end taper ratios T/t (Fig. 1), the diameter ratios D/d, and the plate-length ratios A/a of the core models are equal to those of full-size bushings.

This approach allows a more comprehensive evaluation of papers and equalizer schemes than would normally be possible if full-size bushings were tested. The use of corettes also allows bushing designers to choose the paper and equalizer scheme which gives the best balance with regard to dielectric strength, power-factor characteristics, and cost.

In the corettes, the axial dielectric strength is proportional to the radial distance between equalizers and the paper thickness. The paper thickness and radial distance between equalizers are therefore not scaled down, in order to avoid obtaining over-optimistic test results.

For the purpose of carrying out tests, two types of corettes, wound on a miniature winding machine, were built. The first type was made with lined paper, as shown in Fig. 2, and the second consisted of five equalizers made either with a sprayed controlled-resistance material or copper foil, as shown in Fig. 3. The corettes were treated in a small tank by the method used to treat full-size bushings.

Four types of Kraft paper were used in the construction of these corettes, as follows:—

Paper *A*: Unsized, high-water finish, 0·005-in. thick, 0·95 to 1·05 density, used as a base for lined paper.

Paper *B*: 0·004-in. thick, saturating 0·55 to 0·65 density.

Paper *C*: 0.004-in. thick, saturating 0·65 to 0·75 density.

Paper *D*: 0·004-in. thick, saturating 0·75 to 0·85 density.

Electrical tests were made to evaluate the following factors:

(1) The effect of paper density and radial distance between equalizers on the 60-cps and impulse-breakdown strength of sprayed equalizer cores.

(2) The effect of the paper density of the sandwich layer on the 60-cps and impulse-breakdown strength of a lined paper core.

(3) The effect of varying the sandwich paper thickness on the 60-cps and impulse-strength of a lined paper core.

(4) The power-factor/voltage characteristics of papers with different densities.

All tests were made with the corettes completely immersed in transformer oil in a large tank. Different tanks were used for the 60-cps and impulse tests. The 1-min step-by-step method of test was used during the 60-cps breakdown tests, the voltage being raised in 5-kV increments, beginning at the corona-starting voltage.

A negative-polarity 1·5 × 40-micro-second full wave was used during the impulse corona-starting voltage and breakdown tests. The voltage was raised in 10-kV increments, beginning at the corona-starting voltage, for the

breakdown tests. Three waves were applied at each level, and radio noise and/or corona measurements were made during all tests.

The results of these tests can be summarized as follows:—

An equalizer pattern with 9 turns between equalizers was superior on 60-cps and impulse-breakdown strength to an equalizer pattern with 12 and 15 turns between equalizers, sprayed equalizer corettes made with the highest-density paper *D* having the highest 60-cps and impulse-breakdown strengths. These strengths, insofar as lined paper corettes and sprayed equalizer corettes with 9 turns are concerned, were comparable. The medium-density paper *C* and the high-density paper *D* had about the same 60-cps and impulse-breakdown strengths when used as sandwich papers in lined paper corettes, and these values were not appreciably affected when using a sandwich paper of 0·008 in. thickness, instead of 0·004 in. thickness.

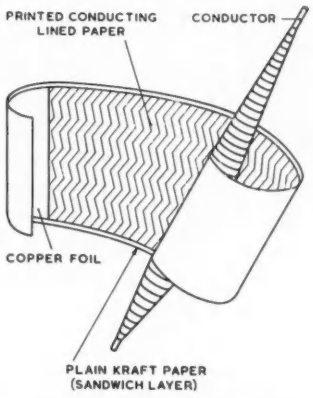


Fig. 2. Lined paper core model.

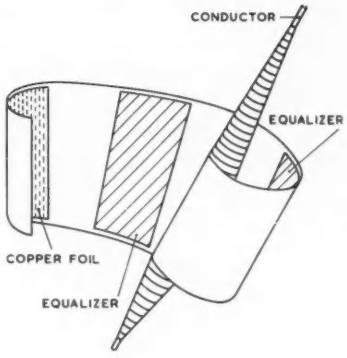


Fig. 3. Copper-foil or sprayed equalizer core model.

All papers had relatively flat power-factor/voltage characteristics, papers *C* and *D* exhibiting approximately equal values of power factor. Corona monitoring during tests showed that there was no damaging corona below either the 60-cps or impulse-voltage withstand-levels. The tests also indicated an adequate factor of safety between the withstand-voltage levels and the breakdown-voltage levels. All corettes failed axially from line to earth during the 60-cps and impulse-breakdown tests.

It is concluded from these tests that basic data can be obtained by means of these inexpensive corettes or core models, with the advantage that better statistical significance is possible at a comparatively small cost by using a larger number of samples to establish correlation. Also, the time required to produce these corettes is short, so that any new material can be evaluated quickly.

Radiation-Resistant Fluids and Lubricants

By W. L. R. Rice, D. A. Kirk, and W. B. Cheney, Jr.

From *Nucleonics*, U.S.A.,
Vol. 18, No. 2, February 1960,
pp. 67–71, 8 illustrations

Radiation-resistant lubricants are of major importance in portable nuclear systems, particularly in extraterrestrial systems, where shielding weight must be kept to a minimum and radiation doses are correspondingly high. Since organic fluids and lubricants are especially susceptible to radiation damage when under thermal stress, both thermal and radiation environments must be considered.

Materials of outstanding capability have already been developed. Thus, solid-film lubricants and greases have been obtained which remain functional at high radiation doses and high temperature levels. Also, base fluids, particularly the meta-linked polyphenyl ethers, have been developed and show promise in numerous applications, such as lubrication and heat transfer, at temperatures as high as 800 to 900°F and at radiation exposures as high as 10^{11} ergs/gm carbon. Development efforts now under way are expected to produce operational capabilities far in excess of those at present available with conventional fluids and lubricants.

Both greases and solid-film lubricants have been studied by a number of organizations, while general fluid developments have been outlined in several reports and a comprehensive survey has been made of fluids for use in nuclear reactors. In addition, work on fluids for use in extreme-temperature systems is in progress, the evaluation of fluids and lubricants under dynamic conditions in the presence of gamma radiation has been undertaken, and a fundamental study of the effects of high-intensity radiation on changes in chemical composition is being conducted.

Solid-Film Lubricants

Solid-film lubricants generally consist of a finely divided solid, such as graphite or molybdenum disulphide, affixed to the bearing surface by a resin bonding agent. Other types, often used in conjunction with liquid lubricants, incorporate the lubricating material in a sintered-metal matrix or employ high-carbon-content alloy bearing surfaces to support some degree of self-lubrication. Solid-film lubricants are designed to require no

maintenance and last the lifetime of the bearing surface.

Although it is true that a number of solid-film lubricants show an improvement in wear life over a wide range of exposures to gamma radiation, it should be noted that the effect can vary from film to film and that gamma radiation alone can play a vastly different role from that of mixed reactor radiation. Thus, tests on one film have shown a marked improvement in wear life when subjected to reactor exposure but a considerable reduction in wear life after exposure to gamma radiation. Solid-state characteristics, which are more critical under neutron bombardment, undoubtedly play an important part in the change in wear life.

Wear-life tests conducted at —65°F indicate that solid films should have unlimited low-temperature applicability. Present resin-bonded films are usable up to about 500°F, with a probable radiation tolerance of 10^{11} to 10^{12} ergs/gm carbon. For higher temperatures and dosages, the metal-matrix type now under development is probably the most likely candidate. Estimates of usable life indicate a possible temperature tolerance up to 1000°F.

Greases

Until recently, the primary drawback to the development of a good high-temperature grease has been the base fluid. Thickeners have been available for several years which possess thermal stability in excess of any usable base fluid. The high-temperature greases formulated to date generally use silicone fluids, but although they possess wide liquid range, low volatility, and high temperature stability, the silicone fluids generally have poor radiation stability and marginal lubricity. This has prompted research for the purpose of developing greases of greater radiation stability.

Of the radiation-resistant greases developed to date, the terephthalamate-thickened alkyl diphenyl ethers are the most promising. These greases are usable at temperatures between —30° and +350°F and at radiation dosages exceeding 7×10^{10} ergs/gm carbon, based on tests following static irradiation.

Dynamic evaluation of greases in the presence of gamma radiation is now under way, including tests on four commercial greases, i.e., a soap-thickened mineral-oil composition, an arylurea-thickened silicone-oil grease, a copper phthalocyanine-thickened silicone-oil grease, and a dye-thickened silicone-oil grease. The data on these greases are incomplete, but it is already evident that operation at temperatures as high as 600°F is possible, even in the presence of gamma radiation. Thus, while tests with these greases in bearings operating at 10,000 rpm showed that the bearings failed comparatively quickly with the soap-thickened mineral-oil grease (with and without gamma radiation), the silicone-oil greases gave markedly improved results. For example, with the arylurea-thickened grease and a test temperature of 450°F, the bearings were operated for nearly 600 hr without gamma radiation before failure occurred and up to about 320 hr with a gamma radiation of $1{\cdot}44 \times 10^{10}$ ergs/gm carbon. The copper phthalocyanine-thickened grease did not give equally satisfactory results, but the dye-thickened grease, at a test temperature of 600°F and with a gamma radiation of $8{\cdot}8 \times 10^{9}$ ergs/gm carbon, enabled one bearing to be operated for about 200 hr before failure occurred.

The outlook for the future is very promising. With the availability of the high-temperature polyphenyl ethers, base fluids are now available which show outstanding thermal and radiation stability, while greases should be available in the very near future which will allow extended operation at temperatures as high as 800°F and down to about 0°F.

Fluid Development

The success or failure of greases, hydraulic fluids, engine oils, and lubricants depends primarily on the capabilities of the base fluid. In the various applications, fluid shortcomings have previously been overcome with additives; for example, for hydraulic fluids, viscosity-index improvers with small amounts of oxidation inhibitors, metal deactivators, or antifoamants are used.

Under high-intensity radiation, base-fluid additives rapidly lose their effectiveness. As a result, research efforts have been devoted towards tailoring a molecule with the necessary stability to oxygen, temperature, and radiation without the incorporation of additives. The result of this work has been the establishing of a sound foundation of information on the polyphenyl ether fluids.

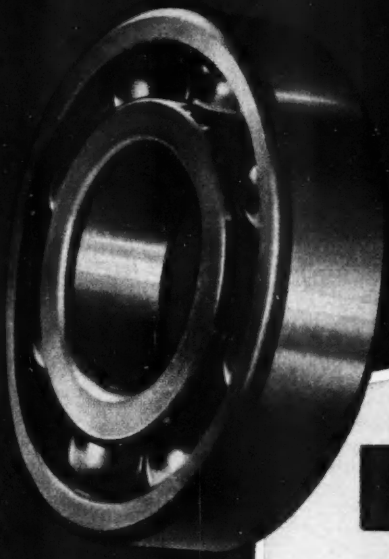
The all-meta isomers of the polyphenyl ethers comprise a series of great versatility, and such isomers are available which satisfy requirements for low melting point, low volatility, a range of viscosities, and high-temperature operation.

As an example of the overall promise of the polyphenyl ethers, it is possible to compare the compound *m*-bis(*m*-phenoxy-phenoxy) benzene with a typical jet-engine oil in current use by the U.S. Air Force. The ether has a useful temperature range almost 200°F greater than that of the jet oil, with an upper temperature limit almost 300°F higher. It has only 4% of the volatility of the engine oil and forms only 1% as much coke at 800°F. The oxidation stability of the ether is over 1000 times greater than that of the engine oil—a significant advantage in extreme-temperature jet-engine operation. Furthermore, the ethers are stable to radiation exposures from five to ten times greater than those which the engine oil can tolerate.

The single class of compounds that appears to be competitive with the polyphenyl ethers appears to be the chain-type polyphenyls, such as meta-terphenyl, etc. These compounds have oxidative, thermal, and radiation stabilities equivalent to those of the polyphenyl ethers and are at present far cheaper to produce. Their drawbacks, however, override their cost advantage and reduce their utility as wide-temperature-range lubricating fluids, as these polyphenyls are extremely poor in lubricity and have much higher melting points.

The radiation stability of aryl ether compounds shows considerable promise. The thermal properties of certain of these ethers have been investigated to determine their usability in a radiation environment. Diphenyl ether, 1,4-diphenoxybenzene, and bis(*p*-phenoxyphenyl) ether have been tested, 3-kg samples of each being irradiated in a 3-MeV Van de Graaff generator under a nitrogen atmosphere with a total dose of 1×10^{11} ergs/gm carbon, using a beam current of 1000 μA with a 10-in. scan.

The results of these tests showed that molecular weight (ebulliscopic) increased somewhat with irradiation, the elemental analyses indicating little change. The melting and boiling points of the compounds were reduced, while their viscosity and vapour pressures were increased. These changes indicate the formation of products of higher molecular weight, as well as more volatile constituents as a result of irradiation. Coke formation increased considerably for all irradiated compounds, but was less severe in the case of compounds of higher molecular weight.



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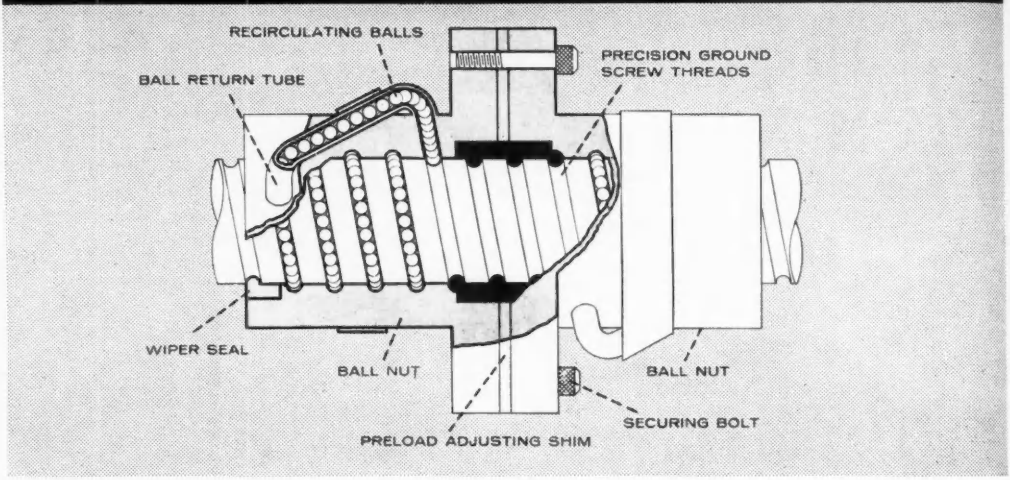

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British Industrial Developments

Automatic Conveyor System for Glass Lamp-Bulbs

As announced by the General Electric Co. Ltd., of London, W.C.2, a new system of automatic conveying of glass lamp-bulbs has been installed at the Osram Lamp Works, Wembley. The system is capable of carrying 20,000 bulbs per hour from the ground floor of the factory to the top floor, where the lamps are made, involving a distance of 250 ft and saving labour and space, as well as cutting down breakages.

As a first stage, the conveyor system has been designed to serve ten production groups for general-lighting service lamps at Wembley. Each group is fed with the bulbs to be used in making lamps, and the handling of them has, in the past, involved a great deal of manual labour. Thus, they were first unloaded from cartons, fitted into trays, and washed and dried, after which they were taken by trolley and lift to the production group. Finally, they were imprinted on the crown with the lamp rating, etc., requiring a total of four separate manual operations, each necessitating many operators. In the new system, however, an operator first unpacks, inspects, and loads the bulbs into trays. The bulbs are then not touched by hand again until made into lamps.

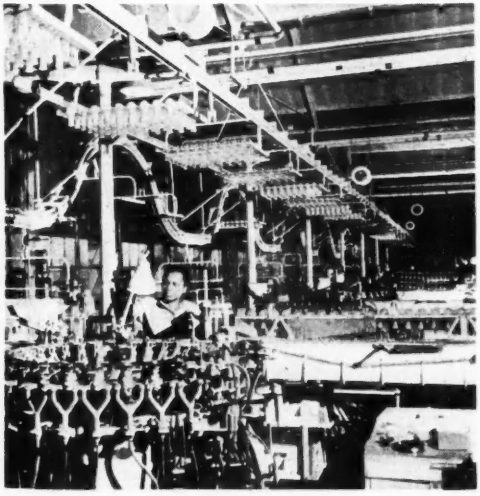

Fig. 1.

On the lower floor, trays are placed on ramps sloping down towards an overhead conveyor unit (Fig. 1). There are ten ramps, each associated with a machine group on the production-floor above. Hangers on the conveyor pass in front of these ramps, every tenth hanger feeding one particular group, and, at the correct instant, a pneumatic lift, triggered by the control system, raises the tray from the bottom of its ramp and places it in position to be taken up by its hanger. The hanger carries the tray to the upper floor, where another control trip deposits the tray on a transfer unit at the right production group,

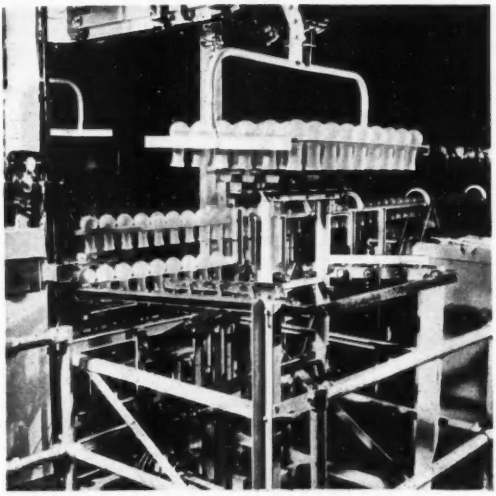

Fig. 2.

the same hanger taking off an empty tray and returning it to the lower floor for reloading. In this way, the bulbs required on a particular group are loaded onto the appropriate ramp downstairs, and are delivered only to the group for which they are intended. Thus, although each group may be using different bulbs, all of which are carried on the one conveyor, they are automatically distributed to the correct group. Fig. 2 shows a tray of bulbs arriving at the unloading unit feeding one of the production groups.

A full tray accepted by a machine group carries 54 bulbs in rows of 9 bulbs. The tray rolls down another ramp, and the bulbs are removed row by row to a transfer unit, where they are first stamped by an automatic printing machine. They are then washed internally by clean hot water, dried by warm compressed air, and finally loaded onto a sealing-in machine, where they

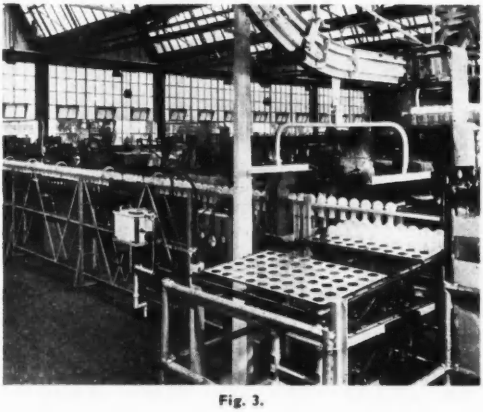

Fig. 3.

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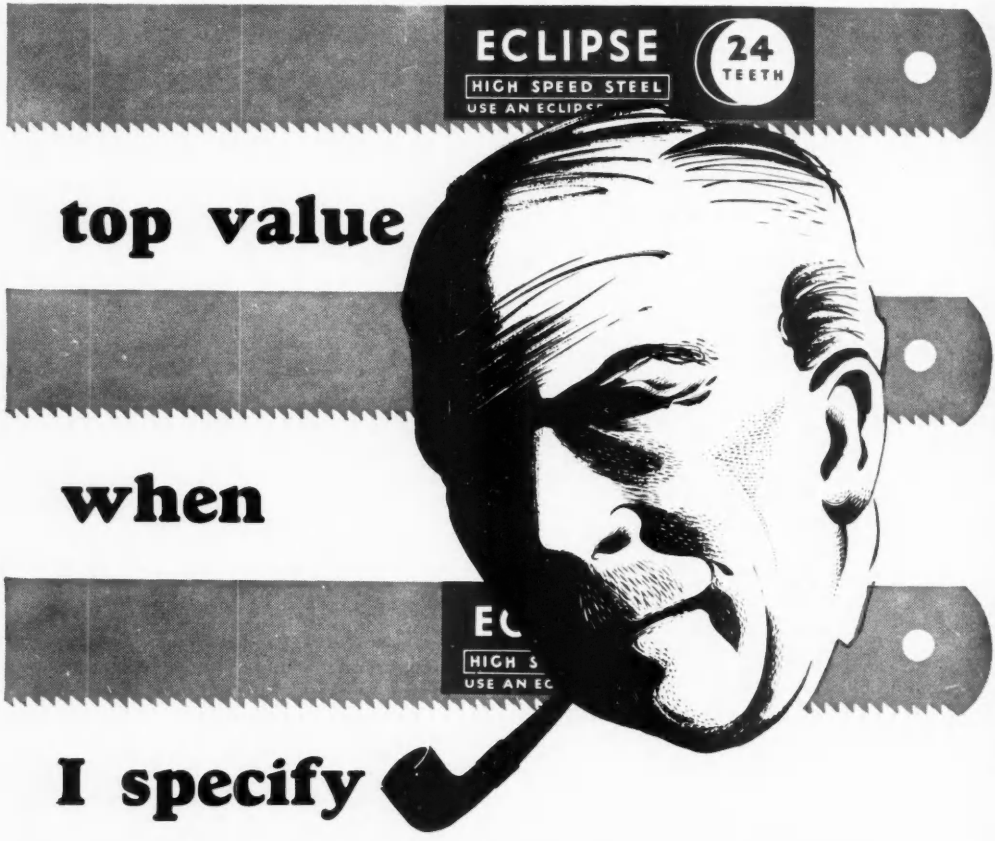

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meet the other components required to produce finished lamps. A general view of the automatic imprinting and washing plant is illustrated in Fig. 3.

The conveyor feeds bulbs to the groups at a slightly faster rate than required, so that a group never has to wait for supplies. When the production group has as many bulbs as it can cope with, a control system is so arranged that the next full tray is not deposited from the conveyor, but carries on and is eventually brought round again for acceptance. This would also happen if the machine group were stopped for any reason. Besides saving labour and space and reducing the number of broken bulbs, the system has another important advantage, in that clean, hot bulbs arrive at the processing machines. As a result, there are no troubles with dirt and condensation on the inside of the glass, as occurred previously when the washed and dried bulbs were standing around waiting delivery by hand.

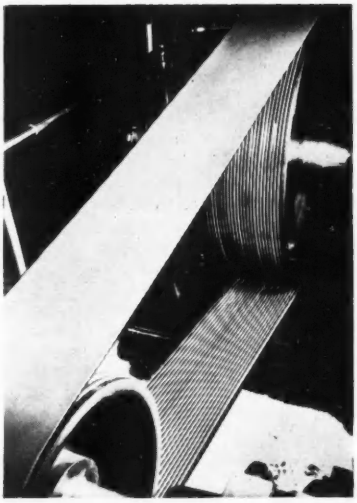
Precision Universal Grinding Machine

Although of French design, the new M.S.A.-300 precision universal grinding machine is manufactured only in the U.K. for home sales and export, including France, by Chambon Limited, of London, W.6. The new machine, which is of exceptionally rigid construction, combines precision and versatility with easy manipulation to facilitate change-over to different types of grinding, independent workheads being available for cylindrical grinding, for tool and cutter grinding, and for hobs and spiral cutters.

Both the longitudinal and transverse movements are hydraulically operated and are infinitely variable in speed, with the added advantage on the transverse movement of rapid retraction from the workpiece for checking purposes, followed by a rapid return to the original position, as governed by a dead-stop. The transverse carriage is fitted with long guides and supports the column, which pivots around its vertical axis. The wheelhead is mounted on the column in prismatic slides and moves in a vertical direction, while the wheel spindle can be rotated about its horizontal axis. Consequently, the grinding wheel can be positioned to fulfil any requirement. A further feature of the machine is a micrometer diamond dressing attachment for internal grinding. This attachment permits the grinding wheel to be dressed to a preset dimension, after which it can be returned to its original position by a feed indicator.

"Poly-V" Belt Drives

Originally introduced in 1954 by Raybestos-Manhattan Inc., of Passaic, N.J., the " Poly-V " belt drive has now been introduced into the U.K. by Turner Brothers Asbestos Ltd., of Spotland, Rochdale, Lancs., a member of the Turner and Newall Organization. Incorporating the best features of V-belt and flat-belt drives, the " Poly-V " drive makes it possible to obtain an increase in drive capacity up to 50%, and, at the same time, to achieve simplified installation and maintenance and a marked reduction in vibration problems.



The concept of the " Poly-V " drive is extremely simple, the belt being, in effect, a flat belt with a series of parallel V-shaped ribs moulded on its inner surface. These ribs form the driving surface of the belt and completely fill mating grooves on the pulleys, there being no clearance between the two. An important benefit resulting from this arrangement is that the load-carrying member extends across the full face of the drive, unlike the multiple V-belt drive, where part of the total drive width available is wasted by the space between belts. In addition, the grooved inner face of the belt has about twice the surface area in contact with the pulleys, compared with a multiple-belt drive of similar width. These two principal features mean that the drive can transmit the same load in less space or a greater load in the same space as a multiple-belt drive.

Essentially, the " Poly-V " belt consists of a top cover, an uninterrupted strength member extending the whole way across the width of the belt, and a base portion containing the series of longitudinal V-ribs. The belt runs in specially grooved pulleys, and its ribs fill the pulley grooves completely during embrace. The belt is made from synthetic-rubber compounds and thus has the heat-

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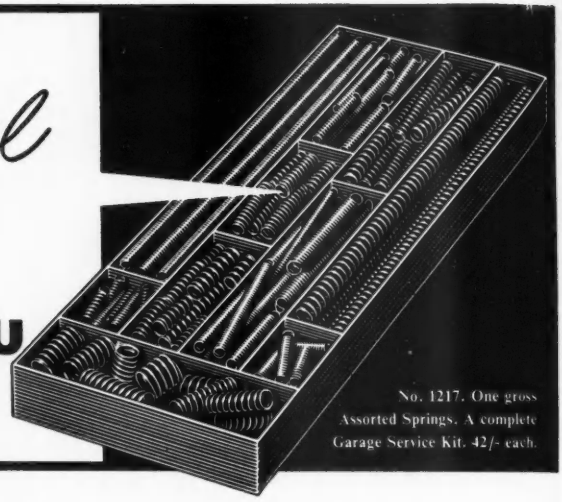

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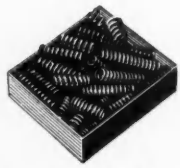

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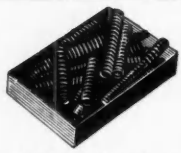

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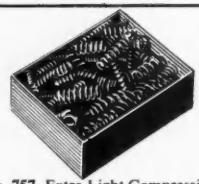

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and oil-resisting properties of high-quality V-belts. The strength member is made from high-tenacity synthetic cords of great strength and resilience to shock, the cords being specially treated to secure the maximum amount of adhesion between the cords and the body of the belt. The base rubber is softer than that normally employed in V-belt construction, allowing it to act somewhat like a hydraulic fluid, completely filling the pulley grooves during belt embrace and exerting an even pressure all over the rib face, thereby securing uniform belt and pulley wear. The rib faces are provided with cover cloths or, in the case of the smallest belts, with special compounds containing a high proportion of fibre.

A further important advantage of the new drive is its versatility and simplicity of installation. Thus, these belts are made in only three basic profile sizes, known respectively as *J*-section, *L*-section, and *M*-section belts, with respective rib widths of $\frac{3}{32}$, $\frac{3}{16}$, and $\frac{3}{8}$ in. and a V-angle of 40 deg. in each case. Of these sizes, the *L*- and *M*-section belts between them cover the entire range of power transmission at present covered by five different conventional multiple V-belt sections. A typical application is illustrated and shows an *M*-section belt, 9 in. in width and with 24 ribs, which has been used to replace ten *D*-section V-belts on a diesel-alternator drive, resulting in a saving of about 40% in pulley width.

The *J*-section belt is chiefly intended for use on light drives where single V-belts are normally used, though it is anticipated that it can also replace a substantial proportion of two-belt and three-belt drives equipped with standard V-belts or V-form link belts in the machine-tool and other general-engineering industries. In this connection, it should be noted that the *J*-section belt has extreme flexibility and offers marked freedom from vibration—characteristics which oversome problems associated with many small drives. In machine-tool drives, for instance, the smoothness of the drive, which eliminates the vibration experienced on other belt drives, also avoids the creation of chatter-marks on workpieces.

Automatic Heat Treatment of Bearing Rollers

The fitting of roller bearings to goods rolling stock as part of the British Railways modernization plans has led to the installation of new heat-treatment plant at the East Works, Daventry, of British Timken. The plant is arranged as a continuous production line in which "Efco" furnaces automatically harden and temper the rollers after deep gas carburizing. The line includes a shaker-hearth furnace with quench tank and electrically operated charge elevator, an endothermic atmosphere generator, and a mesh-belt conveyor furnace, all manufactured by the Electric Resistance Furnace Co. Ltd, of Weybridge, Surrey. Between the quench tank and the mesh-belt furnace there is an "Efco" washing machine designed and manufactured by the Electro-Chemical Engineering Co. Ltd. With the exception of the quench tank and control gear, the production line is installed on an overhead platform, conserving floor space and allowing the quench tank to be accommodated beneath the hardening furnace without excavations.

The rollers to be heat-treated are carried by an electric elevator (seen in the foreground of Fig. 1) into a hopper which feeds them onto the oscillating hearth of the hardening furnace. This hearth, 18 in. wide, is made of nickel-chromium and is actuated in one direction by an electric motor driving an operating cam, and in the other

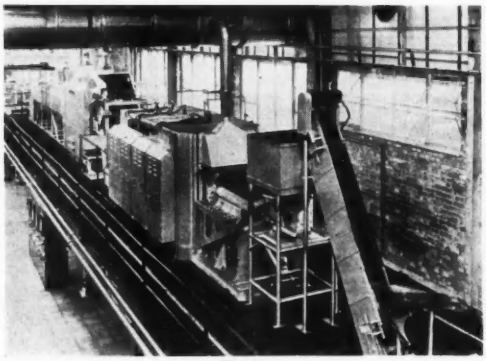

Fig. 1.

by a spring return mechanism. The operating frequency can be adjusted to vary the speed of travel of the parts through the furnace and to allow heating times up to one hour. The rollers enter the furnace chamber through a short heat-insulated vestibule fitted with a fume-removal hood and having a vertically rising door to allow adjustments to be made to the height of the furnace entrance. This chamber is 8 ft long and is heated by electric radiant tubes. The elements, which are positioned above and below the hearth, can be withdrawn quickly and easily from one side of the furnace without having to close down the furnace, and are arranged in three independently controlled zones, each having its own automatic indicating controller. The temperatures are recorded on a three-point instrument. The shaker-hearth furnace, which provides temperatures up to 950° C. and has a total rating of 63 kW, is supplied with a controlled atmosphere, produced in an "Efco" generator, to keep the rollers free from decarburization.

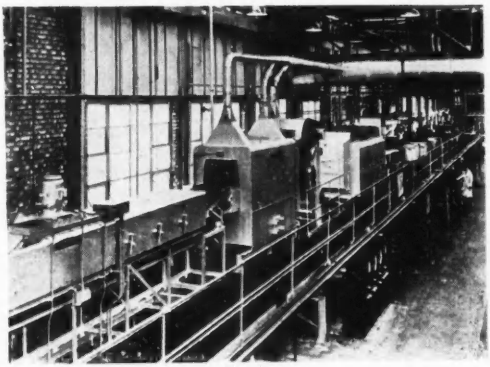

Fig. 2.

The heated rollers leave the furnace by a discharge chute and, to ensure quenching from the full hardening temperature, immediately enter an oil weir on the chute itself. The oil pumped to the weir travels with the rollers into the quench tank, which is an independent and self-supporting unit fitted with overflow and oil-circulating connections. An electrically operated elevator having an endless, perforated, steel conveyor belt fitted with cross flights carries the quenched rollers to the washing machine. Here, in a single-stage gas-heated machine, the quenching oil is removed with a hot detergent spray. The machine is fitted with a wire-mesh conveyor belt, from which the cleaned rollers pass down a chute to be

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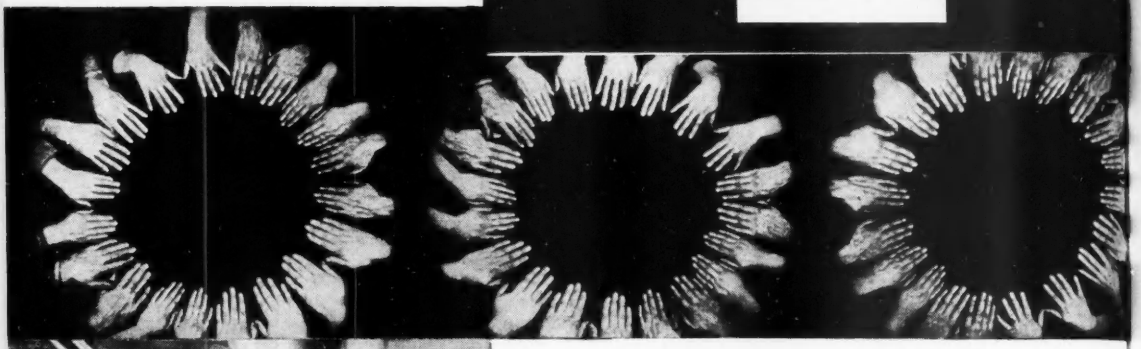

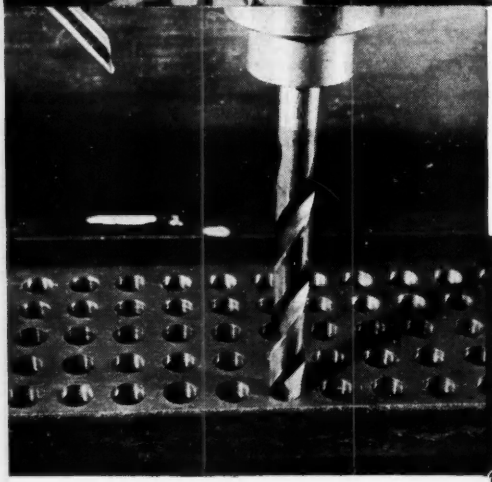

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distributed evenly by guide rails onto the conveyor of the tempering furnace.

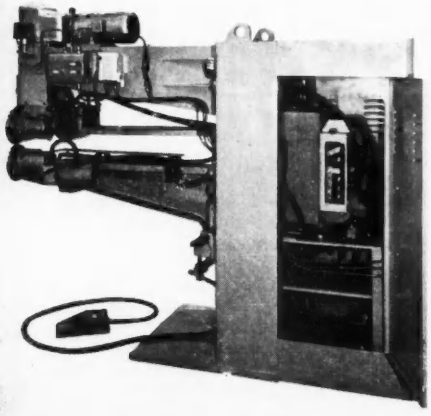
In the tempering furnace the rollers are heated by the forced circulation of an air flow, directed with baffles from a fan in the roof over heater banks and through the chamber, which is 20 ft in length. The furnace has a double casing enclosing the heat insulation, and the heater banks, consisting of nickel-chromium wire spirals on frames, are also mounted in the roof. Temperatures are automatically controlled with a two-point instrument. The tempering furnace, which normally operates at 160°C, but which can supply temperatures up to 300°C, is rated at 50 kW. This furnace can be seen at the left of Fig. 2, with the control panels mounted on the floor beneath the overhead platform.

The complete installation was designed to provide a minimum output of 100 lb of $\frac{3}{4}$-in. diameter rollers per hour, including a soak period of one hour. Without this soak period, the output of rollers is 200 lb per hour but, for a different type of product, could be as high as 300 lb per hour, depending on size-to-weight ratio, etc.

Universal Roll-Seam Welding Machine

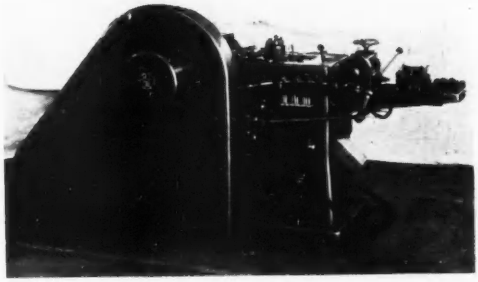
The mass production of drums and tanks, or the fabrication of certain sheet-metal sections, requires the use of seam-welding machines which are both rapid and reliable in operation, and the SAGU 125 air-operated universal roll-seam welder, now being produced in the U.K. for the first time by Electro Mechan-Heat Limited, of Kingston-upon-Thames, has been designed with these requirements in mind. An interesting feature of this Belgian-designed machine is the siting of the motor on top of the upper arm, the drive being transmitted by a vertical shaft and gearing through the air cylinder and welding head to the upper electrode. This compact arrangement of the drive unit, air cylinder, and ancillary controls obviates the array of external shafting, gear-boxes, and knurl drives encumbering a seam-welder in which the motor is in the main structure of the machine.

The SAGU 125 machine can be adjusted for circumferential or longitudinal seam welding simply by rotating the upper head through 90 deg. in either direction, and exchanging the lower arm extensions. The vertical shaft is driven from a 3-phase Kopp variable-speed gear developing 0·5 hp at 1000 rpm, a reversing switch permitting circumferential welds to be made clockwise or anti-clockwise, as required. The shafts on which the upper and lower rollers are mounted revolve in ball-race and needle-bearing assemblies, ensuring reduced friction, as well as numerous line contacts for current transfer. The motor can be set by means of a variable-speed unit to run at 310 to 2800 rpm, giving linear feed rates of 23 to 258 ipm between the electrodes.



High-Speed Double-Blow Cold-Heading Machines

It is announced by the Rockwell Machine Tool Co. Ltd., of London, N.W.2, the sole selling agents in the U.K., that Maschinenfabrik Peltzer & Ehlers, of Krefeld, Germany, have extended their range of cold-forming machines by the recent introduction of six high-speed double-blow cold-heading machines, capable of handling materials from $\frac{1}{16}$ to $\frac{3}{8}$ in. in diameter. The machine illustrated is the model-DKP/S6, which is driven by a 7½-hp motor mounted in the machine base and which can produce bolts or similar components with a maximum shank diameter of $\frac{1}{4}$ in. and a length of 1 in. at a rate of 200 pieces per minute, the motor being coupled to an infinitely variable speed drive providing speeds between 320 and 1425 rpm.



In these machines, power is transmitted to a large-diameter heavy flywheel, which is equipped with an effective foot-brake for stopping the machine quickly after the motor has been switched off. The material is taken from the coil through adjustable rollers on the straightening device by power-driven feed rolls which are provided with a quick-acting pressure release. After being cut off to the required length, the blank is transferred to the heading position, where the preforming punch pushes it into the die before exerting the full force of its blow. Simultaneously, the whole or part of the shank can be extruded to the diameter required. During the next revolution of the crankshaft the finishing punch moves into position in front of the die and completes the heading operation by a single blow. The blank is then ejected from the die, an air jet assisting its downward travel to the chute, from which it falls clear of the machine. A pressure-lubrication system delivers oil to all the necessary points, surplus oil being caught in a large tray contained within the machine base. The position of the punch block carrying the preforming and finishing punches is easily and quickly adjusted, and resetting of the machine for different wire diameters can be effected within a very short time. An inching button is included in the electrical controls to facilitate setting and adjustment.

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ADDITIONAL ABSTRACTS

Numerous important abstracts which, for lack of space, cannot be published in our main editorial columns are regularly included in condensed form in this section. Subscribers may obtain photostat copies of all original articles at cost.

Power, Flow, and Pressure Measurements in Pump Testing

By L. YOUNG and R. A. NIXON
From a paper presented at a meeting of
The Institution of Mechanical Engineers, London,
March 9, 1960, 10 pages, 11 illustrations

THE accurate assessment of pump performance is becoming increasingly important to both manufacturer and user, and, although it is well recognized that pump performance figures are always conditioned by the installation, measuring equipment, test procedure, and interpretation of readings, the true measure of the various effects is not so generally appreciated. This paper is an attempt to examine systematically each of these factors and, in order to provide reliable information about the advantages and limitations of various test methods, is based entirely on results gained by experience under laboratory conditions at the National Engineering Laboratory or from sources to which direct access was available.

Consideration is given both to experimental procedure and to the interpretation of results and, since it has been found that pump performance can be markedly influenced by installation conditions, some typical effects are examined. The main conclusions drawn from experience of pump testing under laboratory conditions, where facilities have been available for investigation of doubtful measurements and apparently unusual performance, may be summarized as follows:—

(1) Where accurate assessment of performance in service is essential, great care must be taken in planning the test installation, and it may be necessary to simulate in detail the intended service installation.

(2) Flow measurement usually presents the greatest problem, and precautions must be taken, even when the highest accuracy is not required, since gross errors can be produced by unsuitable installation or choice of a meter.

(3) The measurement of pump power input by electrical metering of the power supplied to the driving motor may give rise to substantial errors, even where highly accurate electrical instruments are used.

(4) The careful interpretation of measurements (particularly of pressures) is as important as care in making the measurements. The provision of extra pressure tappings in the test circuit to aid analysis is often well worth while.

(5) The use of a standardized test arrangement may give useful comparisons between the performance of different pumps under the standard conditions, but does not necessarily give a true indication of performance in service, particularly at " off-design " conditions.

Spectrum Fatigue Tests on Typical Aircraft Wing Joints

By T. HAAS
From *Materialprüfung*, Germany,
Vol 2, No. 1, January 1960,
pp. 1–17, 24 illustrations

GENERALLY, a true representation of the random loading conditions prevailing in service can be fully accomplished only on structurally unrepresentative specimens, which, however, by reason of their simplicity and small size, enable large numbers of tests, suitable for statistical evaluation, to be made. The other extreme tends towards the complete full-scale structure, when usually only a single test is economically feasible because of the excessive time and cost involved. Not only is statistical information excluded from such work, but the possibilities for simulating the true service loading are also considerably curtailed. The value of such tests for checking the validity of detail testing and for finding weak areas is not disputed.

This paper describes tests aiming at a sufficiently close simulation of the service loading applied to full-scale aircraft component assemblies, i.e., wing joints, in which substantial structural interactions can be represented and/or which, by their liability to fatigue failure, are critical in determining the fatigue strength of the complete structure to which they relate. For such tests, if properly planned, it is practicable to use a sufficient number of specimens to yield information relevant to service behaviour, with an economy in overall effort and expenditure.

As described in this paper, the relationship is investigated between lives estimated by the aircraft industry's standard method based on tests at a constant stress amplitude considered to be the " most damaging " and those obtained purely experimentally by spectrum loading. The advantages of the latter method are established as they concern, in different ways, the " safe-life " and " fail-safe " types of structure, although the distinction between these two terms is shown to be somewhat artificial and inconclusive. The results of spectrum fatigue tests are summarized, mainly in connection with aircraft wing-joint specimens as used in the furtherance of design development and airworthiness objectives, and not in connection with a planned research project. For this reason, owing to the cost of the specimens, the numbers tested are necessarily kept low, but still enable some useful statistical inferences to be drawn. The results also point towards the fundamental issues that remain to be solved by research. Particular attention is paid to peculiarities of the fracture surface resulting from spectrum loading and to the effect of varying load sequences on crack propagation, and the information obtained on crack propagation is utilized for monitoring the operational-life stages of the structure.

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Creep-Forming Titanium with Resistance-Heated Dies

By R. LUDWIG
From *The Tool Engineer*, U.S.A.,
Vol 44, No. 3, March 1960,
pp. 107–109, 6 illustrations

A COMPARATIVELY new forming method, which makes it possible to shape titanium and other brittle materials without tearing or spring-back is creep-forming, in which sheet-metal parts are formed between dies heated to high temperatures. As the range of applications has been extended, efforts have been made to improve the die-heating methods used and to develop improved tools and tooling. As described in this article, one result of this effort has been the development of a final forming fixture which utilizes a resistance-heating method to produce and joggle titanium parts.

To test the feasibility of resistance-heating, resistance-heated dies were constructed for the three most commonly used component cross-sections in aircraft construction, i.e., angle-sections, Z-sections, and C-sections. Stainless steel, 0·09 in. thick, was selected as the die material, as it has several advantages as a creep-forming die material. Thus, it is easy to form in the annealed condition, has excellent scale resistance to 1600°F, is easily welded, and retains approximately 40% of its strength at 1200°F. Die heating was effected with a 100-kVA resistance-heating machine, set to maintain the required temperature, which was held for 3 min to creep-form the part. Forming temperatures for various titanium materials ranged from 600° to 1200°F.

All three fixtures proved satisfactory for physical strength, and there was no noticeable scaling of the dies at temperatures to 1200°F. No trouble was encountered when loading or unloading parts. Good joggles were formed in all parts, owing to the fact that the joggles were formed at high temperatures and also because the forming pressure is normal to the joggle area. Parts produced in the fixtures had satisfactory contours and cross-sections, fitting without clearance when placed back in the dies after forming.

Heat-Transfer Processes in the Combustion Chambers of Aircraft Gas Turbines

By A. H. LEFEBVRE and M. V. HERBERT
From an advance copy of a paper received from
The Institution of Mechanical Engineers, London,
February 1960, 12 pages, 16 illustrations

MOST of the problems in aircraft combustion chambers are confined to the two extreme levels of operating pressure. Performance requirements associated with chemical reaction rates, such as high combustion efficiency and the ability to relight, are most difficult to meet at the lowest operating pressure. As the pressure is increased, reaction rates become less significant, and the main problem is a mechanical one of providing a flame tube to withstand the combined effects of high buckling load and high metal temperature.

It is generally recognized that the situation with regard to high metal temperatures would be eased considerably if a reliable method of estimating flame-tube temperature could be established. Any such method must, of course, be based on an understanding of the various heat-transfer processes involved, and it is the object of this paper to review existing knowledge of these processes.

The paper analyses the relevant heat-transfer processes occurring in gas-turbine combustion chambers, and a general equation for flame-tube temperatures is derived. This equation is used to determine the effect on flame-tube temperature of changes in the operating conditions of pressure, inlet temperature, and air mass flow, and experimental evidence confirming the predictions of the general equation is provided. The effect on metal temperatures of simultaneous changes in all these three variables has also been studied, with the following conclusions:—

(1) Flame-tube temperatures increase with an increase in pressure, an increase in inlet temperature, a decrease in air-mass flow, and an increase in flame-tube size.

(2) At constant engine rotational speed, flame-tube temperatures increase with increasing aircraft forward speed and decrease with increasing altitude.

(3) On rig tests, if actual engine values of flame-tube temperature are to be reproduced, high inlet temperatures should be achieved using a preheating process which does not involve vitiation of the inlet air. If vitiation is used, then additional oxygen should be injected upstream of the test chamber to replace that used in the preheat combustion process.

The Dynamic Stability of Gas-Lubricated Bearings

By V. N. CONSTANTINESCU
From *Revue de Mécanique Appliquée*, Roumania,
Vol 4, No. 4, 1959,
pp. 627–642, 10 illustrations

ALTHOUGH gas-lubricated bearings are finding steadily increasing application, particularly in the case of high rotational speeds, it is none the less true that their practical achievements have reached a more advanced stage than the theory relating to their behaviour. This is especially manifest with respect to the dynamic stability of high-speed bearings, in which instances of dynamic instability frequently occur. The problem of stability in gas-lubricated bearings is, in practice, of considerable importance, as it has a direct influence not only on the life of the bearings, but also on their safe operation. Indeed, in view of the relatively high speeds involved, any trend towards instability may lead to direct contact between the sliding surfaces, to shocks and intense heat, and to seizure of the bearing.

In this paper, the influence of operating conditions on the characteristics of gas-lubricated journal bearings is established, particularly the influence of eccentricity of rotation, and criteria are determined for evaluating their stability. It is shown that the dynamic stability of gas-lubricated bearings cannot be generally relied upon,

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although, up to a certain speed, they may, in fact, be completely stable. Usually, however, gas-lubricated bearings are unstable, at least above a certain critical rotational speed—a conclusion which has been verified by various experimental tests by other investigators. The critical rotational speed n_c at which instability can be expected to appear can be expressed as $n_c = 2{\cdot}84 p_0 \Psi^2/\mu$, where P_0 is the pressure at the point of maximum thickness of the gas film, Ψ is the clearance ratio of the bearing (i.e., the ratio of the radial clearance to the radius of the journal), and μ is the viscosity of the gas.

The main cause leading to dynamic instability is the fact that, although motion is stable in relation to eccentricity, it is unstable with respect to the angle between the resultant pressure and the centre-line, which is not dependent on the value of the eccentricity ratio, i.e., the ratio of the eccentricity to radial clearance. This conclusion is also valid for unstable liquid-lubricated bearings with very small values of eccentricity, and also explains to a great extent the high efficiency of the methods used to promote dynamic stability, such as stepped bearings and the application of pressure.

Eutectic-Cell Count as an Index of Metal Quality

By J. V. Dawson and W. Oldfield
From *B.C.I.R.A. Journal*, England,
Vol. 8, No. 2, March 1960
pp. 221–231, 19 illustrations

The properties of grey cast iron are largely determined by the manner in which solidification occurs. When a hypo-eutectic grey cast iron is cooled from the liquid, a sequence of solidification takes place, in which primary dendrites of austenite which are lower in carbon than the remaining liquid are first precipitated, thus increasing the carbon content of the liquid. During cooling, this process continues until the remaining liquid reaches eutectic composition and, at this stage, the mode of solidification changes, the eutectic beginning to solidify at a large number of separate points or nuclei. Spheroidal aggregates of austenite-graphite eutectic, called eutectic cells, grow at each of these points and finally engulf the skeleton of dendrites previously solidified.

The solubility of some trace impurities sharply decreases on solidification of the metal, and these impurities therefore tend to be concentrated into the remaining liquid, continuing until the last liquid to solidify contains a relatively high concentration of impurities. When solid, it forms a " shell " surrounding each eutectic cell, and it is this shell which makes it possible to reveal the outline of the eutectic cells as a network on a cut surface. The number of nuclei in a unit volume of liquid iron from which eutectic cells grow, has been termed the degree of nucleation, and, in recent years, the degree of nucleation and the number of eutectic cells per unit volume of a casting have been shown to influence a number of properties of cast iron, stimulating interest in the measurement of eutectic-cell number as a means of representing casting quality and for control purposes.

Several methods of eutectic-cell counting have been proposed from time to time, and it is the purpose of this paper to describe in detail the methods available and to present some experimental data to indicate the conditions under which each method may be used successfully. A simple projection microscope is described which enables comparison of numbers of cells to be made. Three methods of comparison of eutectic-cell numbers in castings made in irons of similar type have been investigated and their merits and limitations are assessed. It is pointed out that area and line counting are most suitable for research work, but for routine control in foundry conditions the comparator method is quickest and, provided that the cell pattern is well defined, is very satisfactory.

A Method of Measuring the Resistivity of Protective Coatings on Metals

(*Concluded from page 97*)

the input impedance of the oscilloscope is not infinite, the switch also enables the cell to be shunted during the measurement of voltage. In the final calculation of electrical resistivity, account is, of course, taken of the value of resistance R_1. The sensitivity of this method makes it possible to measure extremely high values of resistivity, using a current of less than 1 μA/dm^2. The measurements were carried out at a frequency of 20 cps, this being the minimum usable frequency permitting a persistent image to be obtained on the oscilloscope screen. The low frequency gives a more clearly defined instantaneous voltage drop, in comparison with the capacitive drop, and is an advantage for accurate readings.

The resistivity of protective coatings was also measured periodically during corrosion tests to determine their behaviour, the electrolyte being renewed every 72 hr over a period extending up to 45 days. Various types of rust- and fungus-inhibiting alkyd, phenolic, and vinyl coatings were tested, and their resistivity curves were determined as functions of the period of exposure.

The experimental results showed that there was good agreement between visually observed conditions and the variation in resistivity values with time. In all cases, provided that the protective coating showed no visible signs of deterioration, the measurements of resistivity tended to remain at a constant high level. A marked falling off in resistivity coincided with the appearance and development of corrosion centres, cracks, and bubbles. In most cases, however, initial variations were noticed during a preliminary period, during which the coating settled to a stable condition after its first contact with the electrolyte. Consequently, comparisons of coating behaviour were based on the portions of the curves obtained after this initial phase (which may be regarded as an " initial soaking " period) was completed.

In conclusion, it can be stated that periodical measurements of the electrical resistivity of a coated metal surface give a valid indication of the degree of corrosion protection provided by the coating. The measuring method used makes it possible to obtain quantitative values for the behaviour of coatings, and can replace visual observations. The tests can be either continuous or intermittent, and the results can be used for comparative assessments of the corrosion resistance of various coatings.

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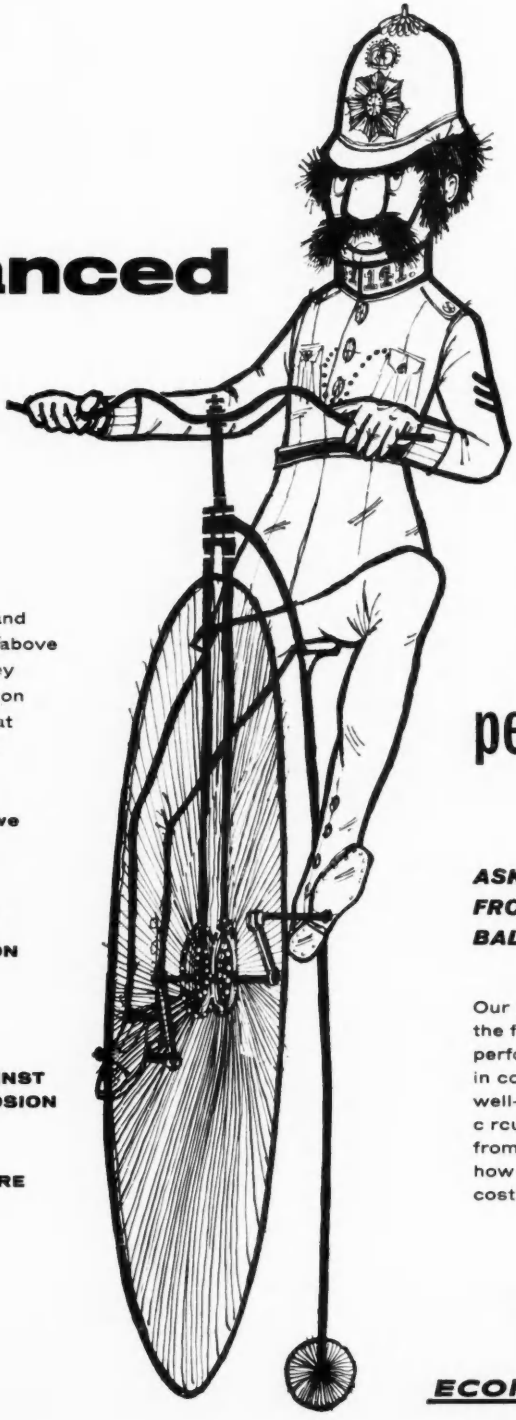

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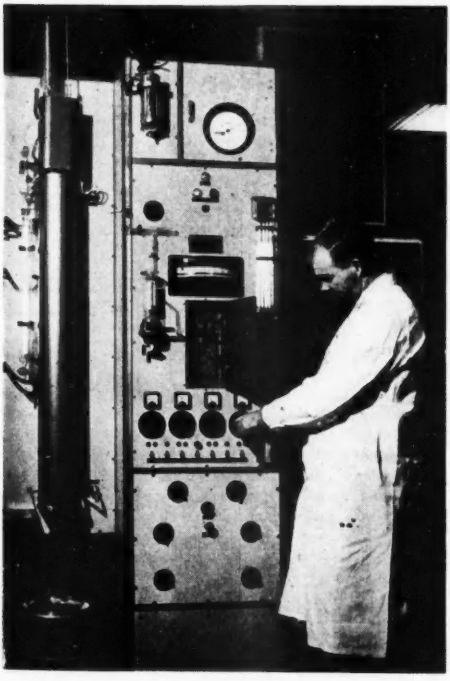
The normal charge to the unit is 4 litres, enabling a sufficient quantity of each fraction to be obtained for subsequent analysis and refining treatment. The dimensions of the standard column are 36 mm internal diameter, 1370 mm length, and 1220 mm packed length, the standard packing being stainless-steel boot eyelets, giving a plate efficiency of 14, though alternative packings can be supplied to suit requirements and in special cases to increase plate efficiency considerably. The column operates under adiabatic conditions.



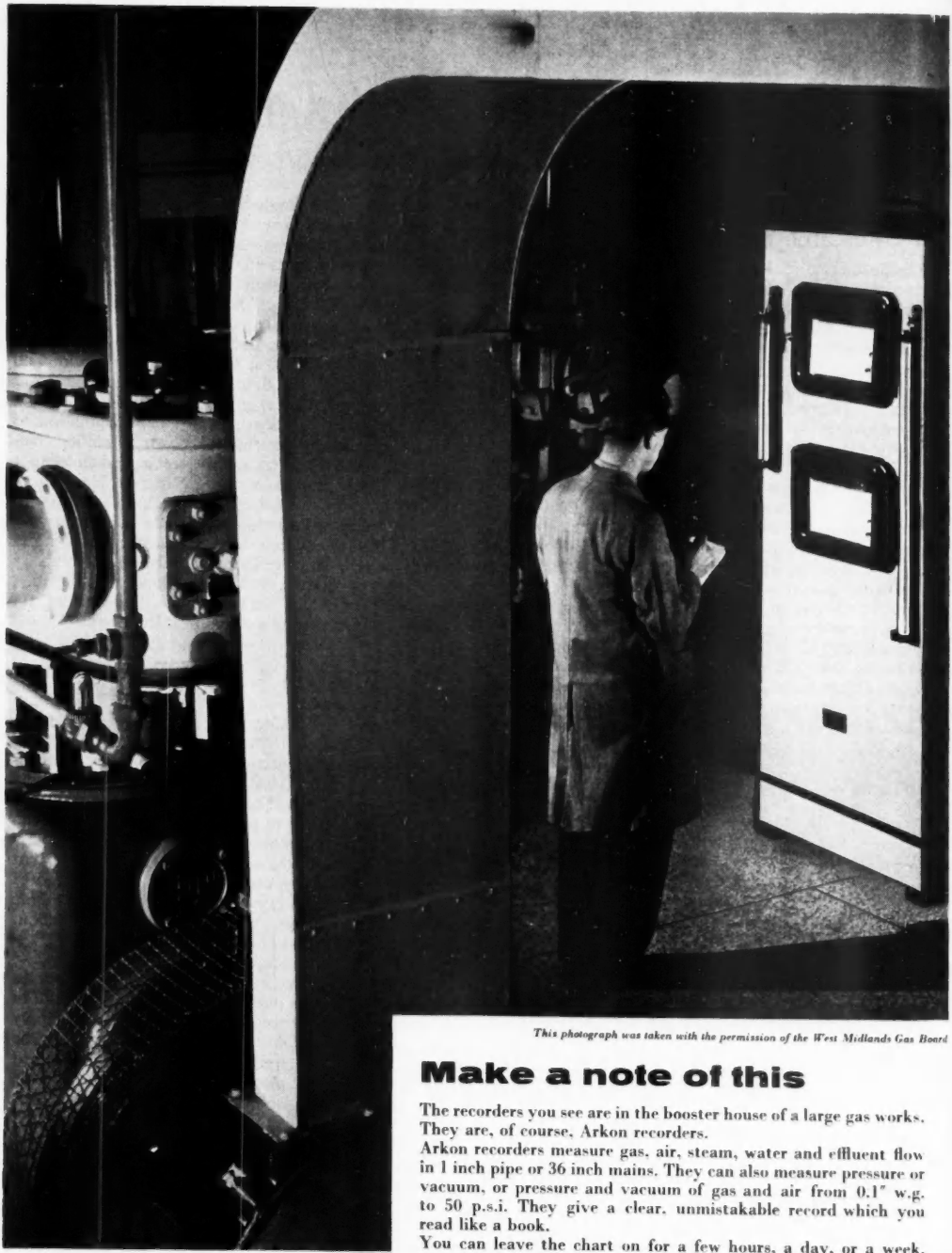
In the assay of crude oil, it is possible to obtain complete data by means of pilot or semi-scale equipment in which the essential features of the large-scale refinery unit are duplicated. Such methods are, however, costly, and most designers of plant prefer a more general type of assay which involves a true boiling-point distillation and the preparation of yield data and curves of the significant properties of distillate fractions. The B.P. distillation equipment gives a sufficient degree of fractionation to enable these data to be obtained. Narrow boiling fractions can be analysed separately or blended in aliquot proportions to produce a number of possible refinery specification products for analysis, etc., including gasolines, reforming naphthas, white spirits, kerosenes, and gas oils. The residue from the distillation can be utilized to prepare a series of residues of differing cut-points by back-blending with the distillate fractions. Alternatively, the residue can be distilled further in a high-vacuum still to obtain lubricating oil and bitumen fractions.

High-Temperature Flame-Cutting Lance

As announced by the Linde Department of the Union Carbide International Company, a Division of the Union Carbide Corporation, of New York, the new " Oxweld " ACL-4 powder lance is capable of cutting through concrete, metal, or any other known hard material of any thickness. In fact, materials which formerly have proved difficult or impossible to pierce with other methods can be pierced or cut with comparative ease with this powder-lancing method. For example, field tests have shown that concrete, 18 in. in thickness, can be cut at a speed of approximately 2 to 3 lineal feet per hour, while a hole can be pierced through an 18-in. concrete wall in about 2½ min, i.e., at a speed of more than 7 ipm.

The key to the successful operation of the new ACL-4 powder lance is accurate control of intense heat. Lengths of standard black iron pipe are fitted into the front end of the lance, which is connected to a source of oxygen supply and a special " Oxweld " metallic powder mixture. The oxygen and powder are mixed in the pipe and are carried to the material being pierced or cut by the consumable pipe. The mixture is ignited at the end of the pipe, producing an extremely high-temperature reaction, estimated at about 8000°F, and capable of melting both ferrous and non-ferrous material in its path. On materials such as concrete, a special mixture of iron and aluminium powder, known as " Oxweld " No. 201 lancing powder, is used, the aluminium further intensifying the cutting reaction. In the case of concrete, the average rates of consumption per square foot of concrete cut are 1000 cu ft of oxygen, 40 lb of " Oxweld " No. 201 powder, and 10 ft of standard black iron pipe.

As extensive field tests indicate that there is no practical limit to the thickness of material that can be pierced by powder-lancing, it is expected that the new



The keen eye will be able to pick out in this photograph an Arkon Liquid Flow Indicator on the pipeline above, and Arkon Full Scale Pressure Gauges on the panel itself.

This photograph was taken with the permission of the West Midlands Gas Board

Make a note of this

The recorders you see are in the booster house of a large gas works. They are, of course, Arkon recorders.

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lance will find widespread use in the construction and steel industries. On construction and demolition jobs, for example, the lance can be used to make vertical and horizontal cuts in concrete without noise or vibration. It is especially valuable on jobs where blasting cannot be employed, where mechanized methods are too costly, or where time is an important factor. Also, in steel mills and foundries, time-consuming jobs, such as opening slag pockets, cleaning soaking pits, etc., can be handled faster and far more efficiently. Operation of the lance is simple, and those who are familiar with oxy-acetylene welding and cutting apparatus should experience no difficulties. The forward end of the lance mounts a quick-release chuck-type pipe holder, and unthreaded pipe or tubing can be inserted or removed quickly and simply.

Pneumatically Operated Floating-Piston Pump for Liquids

Eliminating the need for such moving parts as a motor, drive shaft, packings, or seals, yet providing very efficient positive displacement of any liquid, irrespective of its viscosity, a new type of pneumatically operated floating-piston pump developed by the Crossley Machine Company, of Trenton, N.J., can be used to pump an extremely wide variety of materials, ranging from water and beverages to ice cream, acids, syrups, sludge, greases, mud, paints, and even concrete.

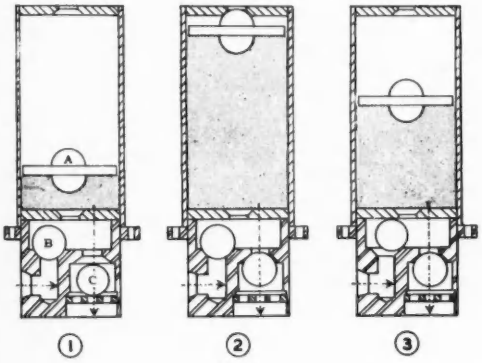

Fig. 1

Basically, the pump comprises three cylindrical chambers, with a free-floating piston in each cylinder and two ball check-valves in each base unit, the three cylinders being filled by gravity and emptied in sequence by compressed air. The operating principle is simple, as illustrated in Fig. 1, in which cylinder (1) is shown discharging, air under pressure, introduced through the top of the cylinder, exerting a downward pressure on the free-floating piston *A* and closing the inlet valve *B* and opening the outlet valve *C*. The ball on the lower part of the piston seats in the outlet before all the fluid is evacuated, so as to seal compressed air in the chamber. Cylinder (2) is shown completely filled and at rest, the air charge being switched to this cylinder by a timing-control system just before the flow from cylinder (1) stops, ensuring an uninterrupted air-free flow, while cylinder (3) is shown in the process of being filled. It should be noted that any chamber can be stopped while the other two continue pumping.

Each chamber is lined with stainless steel and comprises a top plate, a replaceable cylinder sleeve, and an inlet-outlet base unit. Normally, the pistons and ball check-valves are made of nylon but, for abnormal temperatures, e.g., pumping molten metals at temperatures up to 2000°F, pistons and valves of appropriate materials are available.

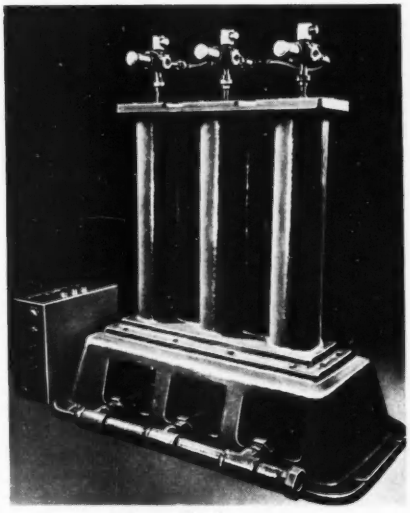

Fig. 2

As the pistons float on the charge, turbulence is eliminated and air absorption is minimized. It is stated that flow is absolutely smooth and air-free, that pulsating and surging are eliminated, and that the pump is noiseless and vibrationless. Furthermore, no safety or relief valves are required and, when a stoppage occurs, the pump itself stops. Other advantages are that the pump can be submerged in tanks or installed in mines, explosive plants, or other areas which are too dangerous for other types of pumps. Also, because each chamber is made of stainless steel, there are no contaminating surfaces, while cleaning can be effected simply by flushing through the inlet, and any component can quickly be reached merely by removing a few bolts.

The dimensions of the new pump, a general view of which is shown in Fig. 2, are about 45 × 24 × 53 in. high, the basic capacity being 100 gpm, though this can be varied by changing the air pressure and the size of the inlets and outlets. The weight of the pump, with its cast-iron jacket and base, is about 1000 lb.

High-Temperature Thermosetting Electrical Tape

A new high-temperature electrical tape, announced by John Gosheron & Co. Ltd., of London S.E.11, is based on I.C.I. 0·001-in. Melinex film and has an extremely stable key-coated thermosetting adhesive, carrying a guaranteed storage life of one year from the date of manufacture. After curing at recommended temperatures, the tape, designated "Transonex" thermosetting tape, will operate up to 180°C without deterioration.

The new tape is stated to have excellent electrical properties, a high tensile strength, and outstanding resistance to acids and alkalis. It can be employed on applications involving solventless impregnation and varnishing and is available in a range of standard widths in 72-yard rolls on 3-in. cores.

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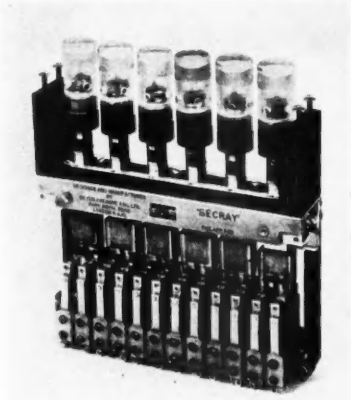
Precision Push-Button Switches for High-Frequency Applications

Stated to be the only one of its type to be mass-produced in the U.K., a new precision push-button switch, designed and shortly to be produced by Seton Creaghe Ltd., of London, N.W.10, should be a valuable addition to the range of multi-channel equipment now in use in a variety of industries. The switch is particularly suited to high-frequency applications and is designed to reduce maintenance and the likelihood of mechanical breakdown. In this connection, the prototype is being tested to a life of 1,000,000 operations. Tests have been made for a contact rating of 50 V, 250 mA d.c. non-inductive, and contact resistance is less than 0·02 ohm throughout life. The capacitance between contacts is less than 2 pF between springs and less than 1 pF between sets.



The switch can be made with any number of buttons up to 16, and the buttons can be illuminated, if required. Each button has a standard contact arrangement of two double-pole change-overs. Only one push-button can be operated at one time, and the contacts of the operated button are cleared before a new contact is made. This arrangement can be altered to give " make " or " break ", and electro-mechanical interlocking facilities are available. The switch can be banked horizontally or vertically. The prototype bank of switches, with the front panel removed, is shown in the illustration.

Tape for Sealing Threaded Connections

Manufactured from P.T.F.E. and capable of being used with a wide range of fluids, including such materials as caustics and corrosive acids, " Thredseal " tape, announced by the P.T.F.E. Division of Crane Packing Ltd., of Slough, Bucks., is stated to represent one of the simplest, cleanest, and most efficient methods of sealing threaded connections ever devised. The tape can be used on threads formed in plastics, aluminium, stainless steel, ceramics, and, indeed, in virtually any material, and works equally well on imperfectly formed threads. Furthermore, it is self-lubricating and prevents galling and seizing. Connections can be drawn up to a greater degree of tightness than with conventional sealing materials and, as the tape never hardens, joints can easily

be broken, if required, even after very long periods. Other advantages are that it can be used to seal against very high pressures and temperatures ranging from —200 to +500°F, and that it is non-toxic and does not contaminate fluids with which it is brought into contact.

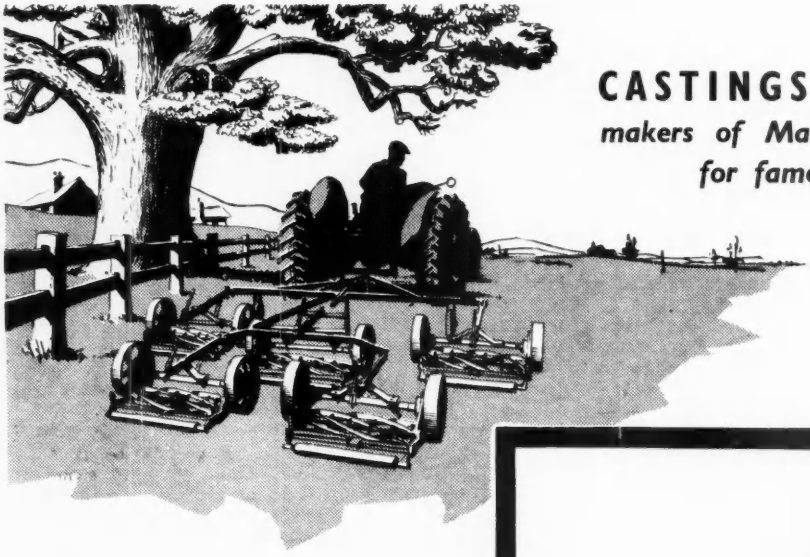
Installation of the tape, which is supplied in standard reels of 4 ft × ½ in., is extremely simple:— A length of tape, sufficient to wrap around the pipe threads with an overlap of about ½ in., is cut from the reel and the end is laid on the male thread and held in place by hand. The free end is then drawn tightly around the threads, so that it conforms with the threaded surface, and is pressed in firmly at the overlap, causing the tape to hold in position by itself. The connections with the female thread are then made up in the normal way and tightened, the tape filling up voids in the threads and automatically providing a positive seal.

Split-Type Precision Mechanical Seals

In the new " Sectaflex " split-type mechanical seal announced by Flexibox Limited, of Trafford Park, Manchester 17, the problem of providing a rotary seal whose wearing parts can be easily and rapidly replaced without stripping down the shaft has been solved. Thus, replacement of worn parts merely entails removing a few screws, taking out the old parts, and inserting new parts —a matter of minutes—thereby cutting maintenance time to a minimum. Furthermore, the precision construction of these seals ensures an extremely low leakage rate.

The " Sectaflex " seal, which can be used at pressures up to 100 psig and temperatures up to 300°F, provided that the vapour pressure at the operating temperature of the fluid being handled is less than atmospheric, is a face-type mechanical seal in which sealing action is obtained by arranging for intimate contact between the rubbing surfaces of two assemblies, one of which is held stationary while the other rotates with the shaft. As these components are subject to wear, they are each divided into two halves and are assembled together in accurate alignment with the assistance of a solid locating ring. A third component, a flexible O-ring designed to prevent leakage along the shaft, is also split for ease of replacement.

A unique feature of the design is the means adopted for ensuring that the rubbing faces are accurately aligned at right-angles to the shaft. This is effected by holding the stationary assembly firmly in a seal plate which is itself bolted to the stuffing-box casing. Set-screws in the seal plate itself then enable the relative position of the stationary assembly to be varied within fine limits. An exploded view of the components of a complete " Sectaflex " seal is illustrated and shows (1) the seal plate with



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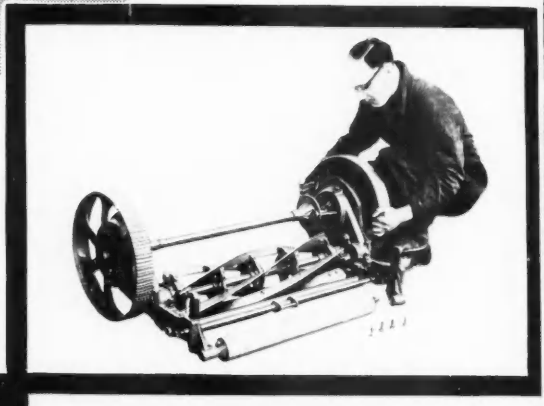

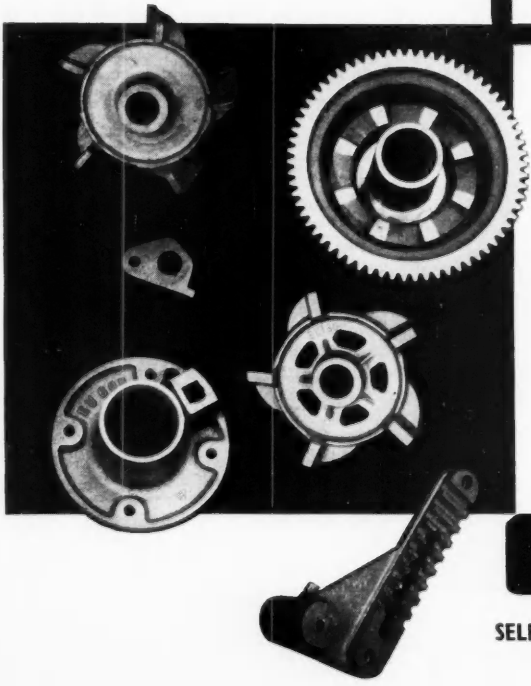

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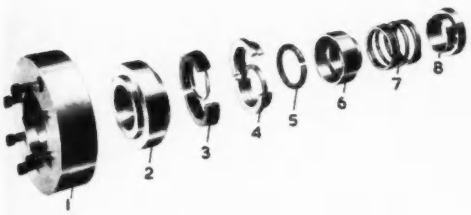
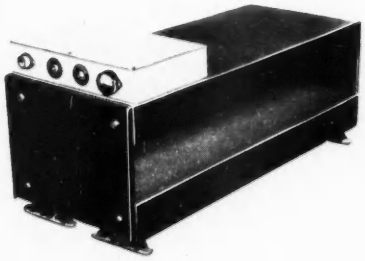


set-screws, (2) the stationary seal-ring body, (3) the split stationary seal-ring insert with solid locating ring, (4) the split rotary seal-ring insert with solid locating ring, (5) the split rotary seal-ring packing, (6) the rotary seal-ring body, (7) the spring, and (8) the spring sleeve.

A variant of the basic design is also available in which provision is made for a positive circulation of the product being handled past the rubbing faces, thereby removing frictional heat, preventing the settling of sediments, abrasives, or polymers, and keeping the seals cool when handling hot products or warm when handling cold products.

Transistorised Tramp-Metal Detector

Combining the advantages of simple installation, robust design, and high sensitivity with low power consumption and the elimination of warming-up time, the new Type-T.L.D. transistorized tramp-metal detector announced by Metal Detection Limited, of Birmingham 12, is fundamentally intended for the detection of ferrous and non-ferrous metal inclusions in such items as packaged food, confectionery, and chemical products, though it can also be used in other applications, including detecting tramp metal in tobacco, plastics, textiles, etc.



The equipment comprises two items, i.e., a power-pack incorporating a relay stage, and the search coil, both units being fully transistorized. The oscillator section, which forms part of the search-coil unit, as shown in the illustration, supplies a high-frequency electromagnetic field to the coil and, when a metal particle embedded in the product passes through the coil, a signal is transmitted to the relay stage, which can be used to operate visual or audible alarms, reject mechanisms, etc. The detector unit is available in a range of sizes to suit belts of from 6 to 24 in. in width, and with aperture heights up to 8 in.

High-Performance Sub-Miniature Micro-Switches

With body dimensions of only 0·5 × 0·35 × 0·2 in. and weighing less than 0·04 oz., a new sub-miniature micro-switch announced by Honeywell Controls Ltd., of Greenford, Middlesex, is believed to be the smallest of its type in the world, and is rated at 24-A surge, 7-A resistive, and 4-A inductive for operation at 28 V d.c. or up to 250 V a.c. The temperature range is stated to be between −65 and +250°F, and a minimum life of 25,000 operations is claimed.

The contact arrangement of the switch, which is designated 1SX1-T, is of the single-pole, double-throw type, and the turret type of terminal design permits easy wiring of strong wrap-around connections. The terminals are plated for soldering. The case, cover, and plunger are of high-strength plastic, and the contacts are of silver, the snap-action spring being made of beryllium-copper. The switch mounts on 0·88-in. centres, one hole being elongated to facilitate positioning. Auxiliary actuators of about the same size, for use with the switch, are also available to suit most applications.

Flexible Printed Circuits and Their Design

(*Concluded from page 91*)

adhesive tape for art-work is fast and effective. For large areas, a translucent red film on a transparent carrier sheet is available commercially. Conductors are outlined on the red film, and a sharp knife is used to cut along the outline. The film between conductors is simply removed to produce a finished drawing. Master art-work may be a composite of the black tape lines and red film, and this is a good method of producing rounded corners and odd-shaped conductors or pads.

Corners, especially inside corners, should be rounded. One dimension, preferably the longest, should be indicated as a guide to proper reduction. Registration marks on the master art-work are necessary throughout the production process to key the positioning.

Art-work is usually made up to four or more times the actual size of the finished circuit. Finished size, size of conductors, accuracies required, and limitations of camera equipment are determining factors. For small pieces, it is sometimes convenient and more accurate to make the art-work larger than four times actual size in laying out lines and spaces.

Large drawings, exceeding camera dimensions, may be made in sections. These can be reduced photographically, and the negatives spliced to produce the finished circuit. Negatives should be butted, when splicing is necessary. A contact print can be made to produce a single piece, with all splicing marks or overlapping of film removed.

If a number of identical conductor patterns must be made, the negative can be prepared from a single piece of art by means of a step-and-repeat camera procedure. Patterns may be either continuously repeated (long cables), or prepared for die-cutting into separate units.

Since printed-circuit etching processes are used in fabricating flexible printed wiring, everything appearing on the art-work can be reproduced in the finished wiring assembly. Consequently, it is only necessary to add such numbers, letters, or other markings at appropriate points to identify the circuit or individual conductors.

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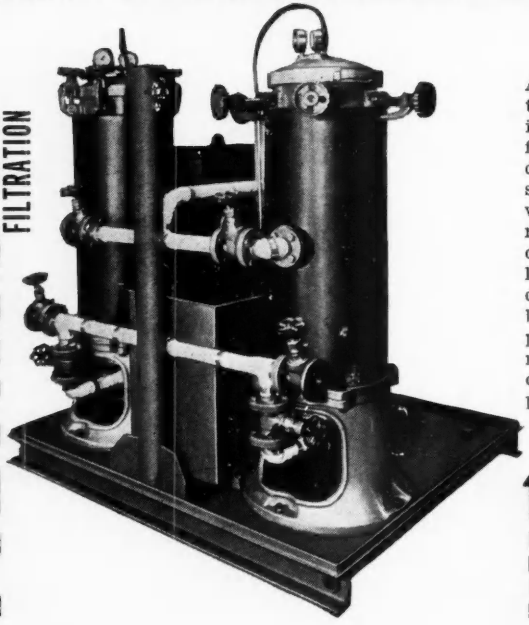

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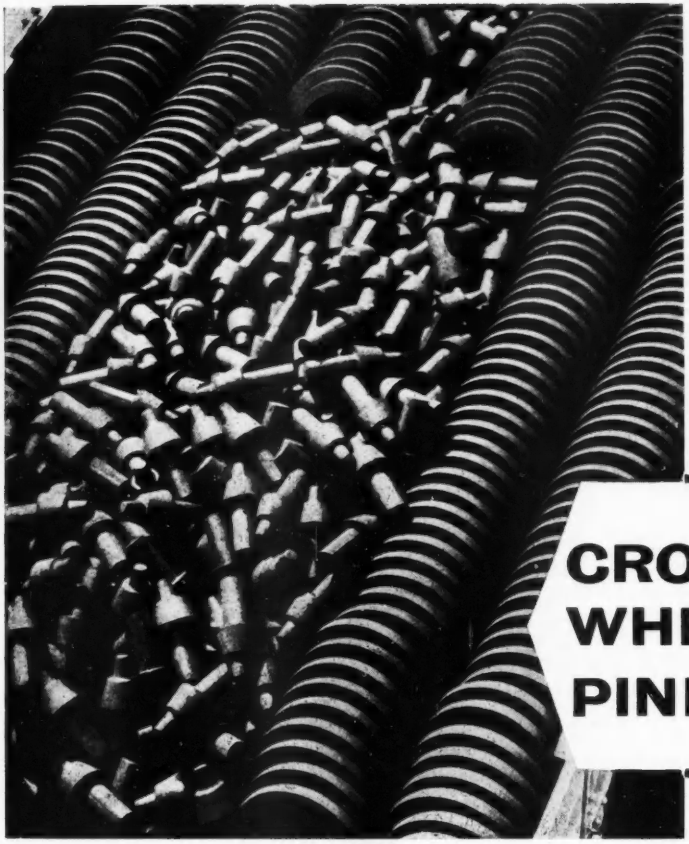

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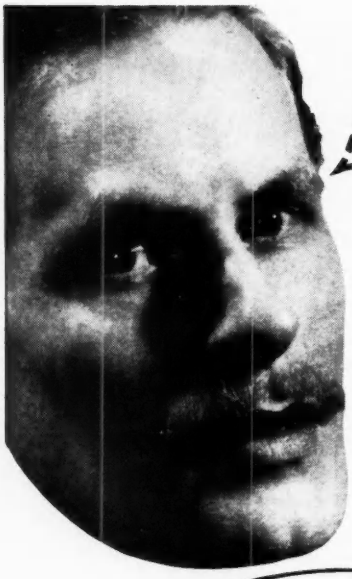

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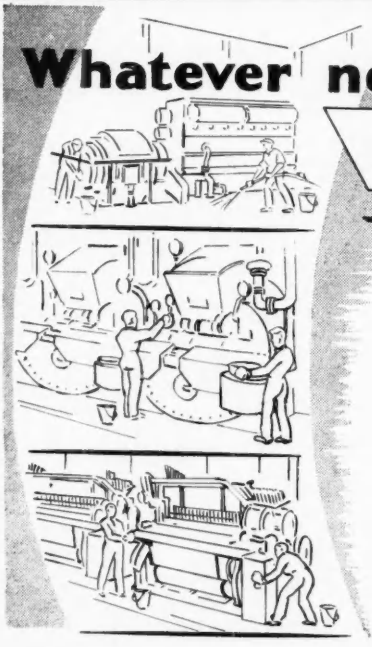

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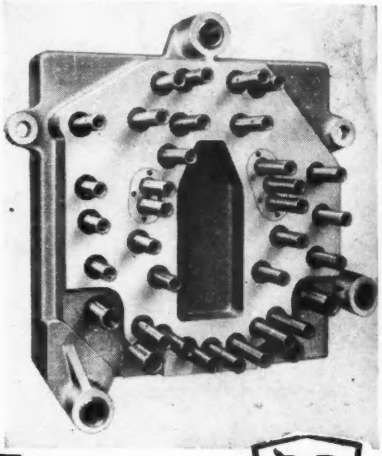

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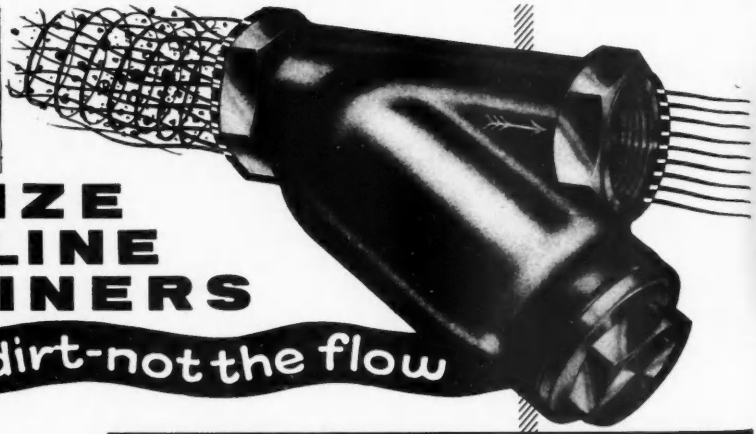

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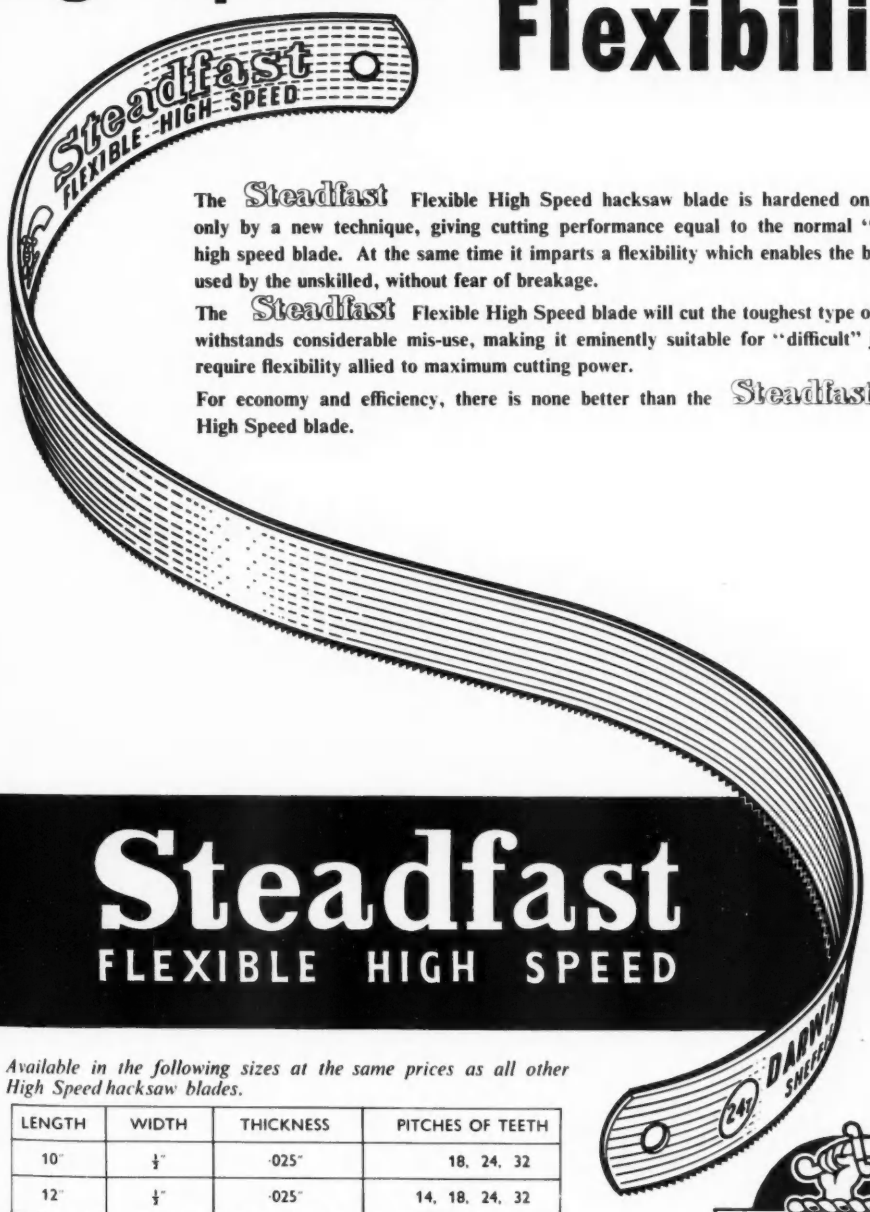

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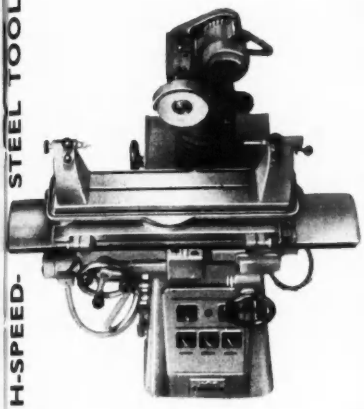

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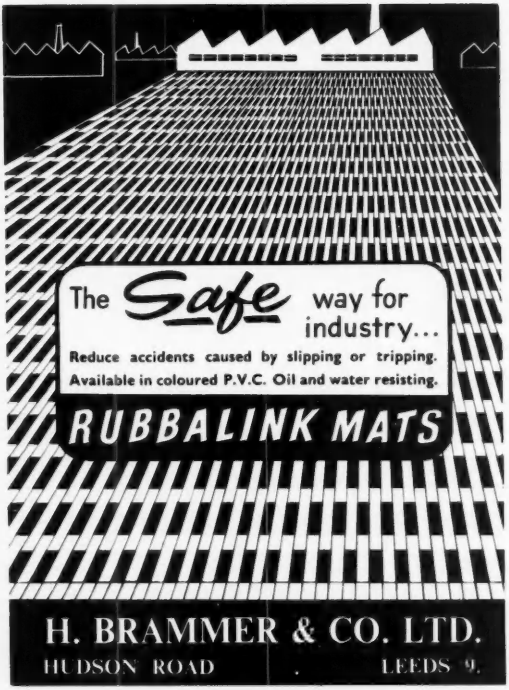
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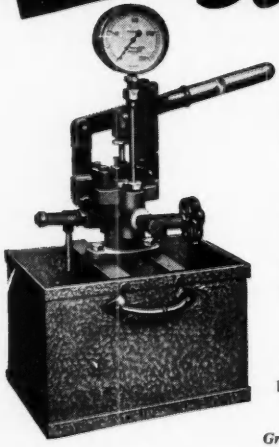

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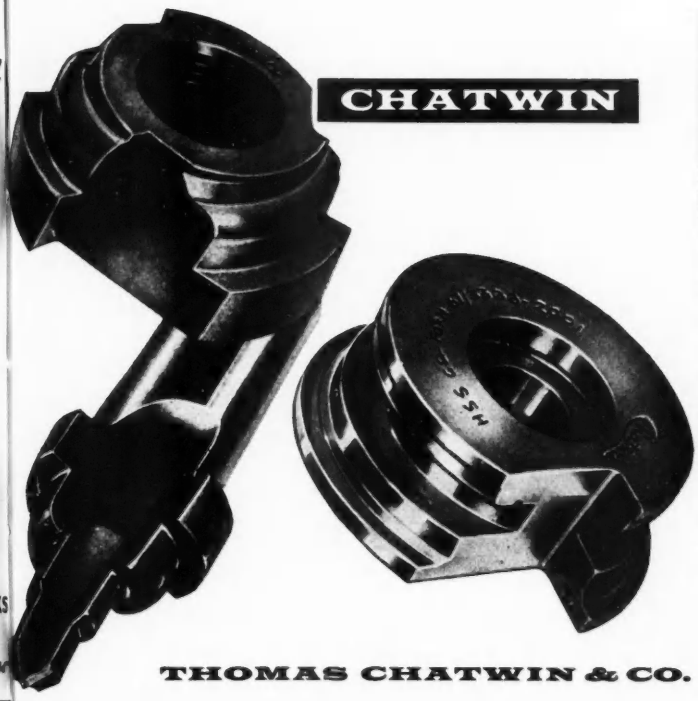

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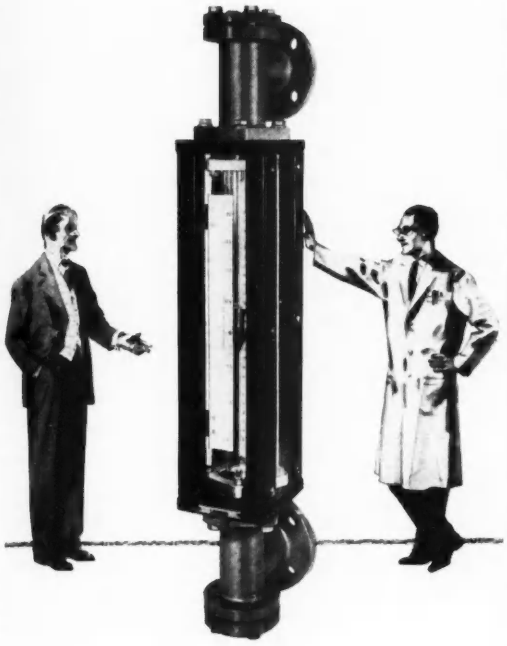

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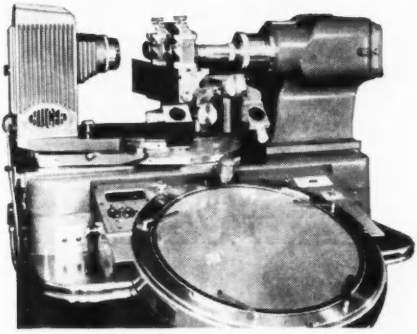

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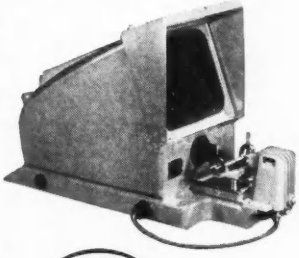

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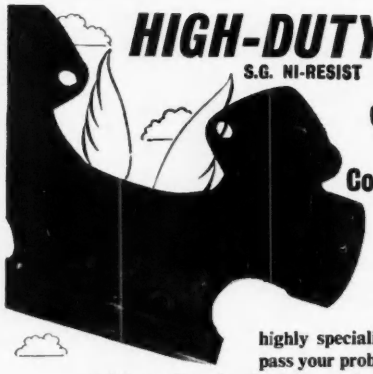

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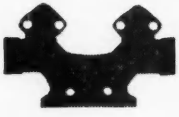

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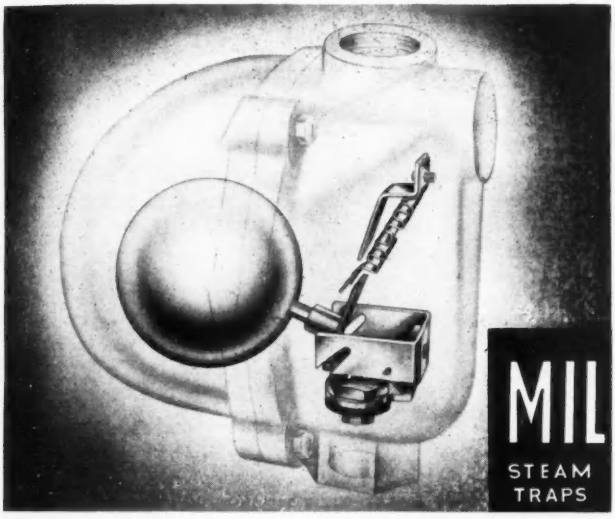

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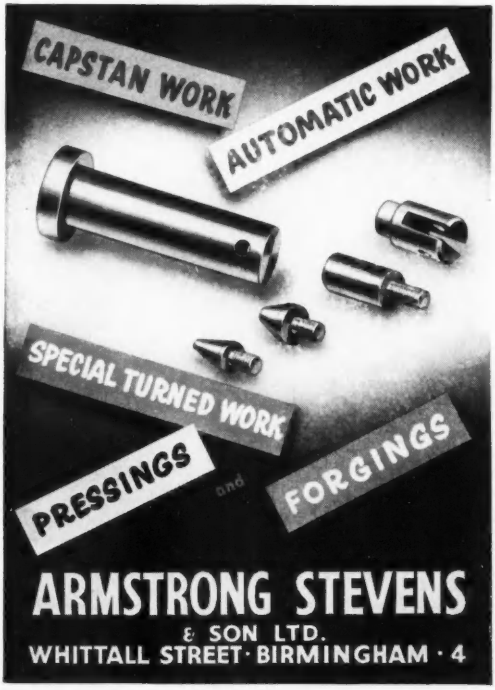

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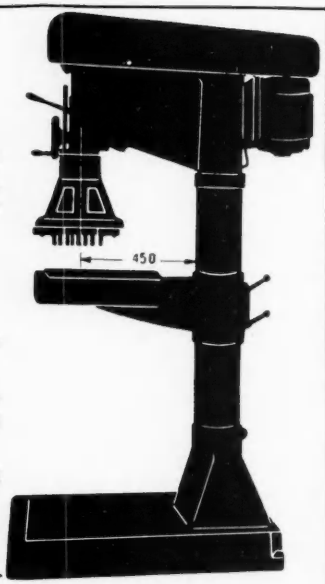

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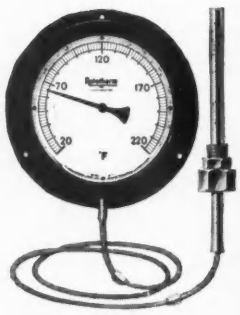

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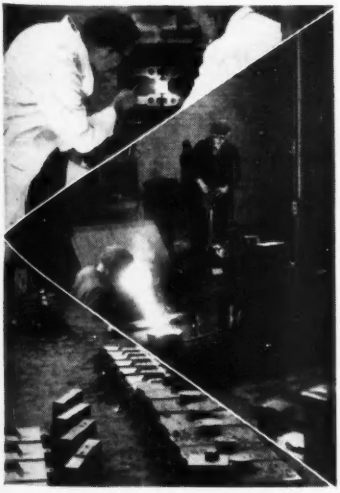

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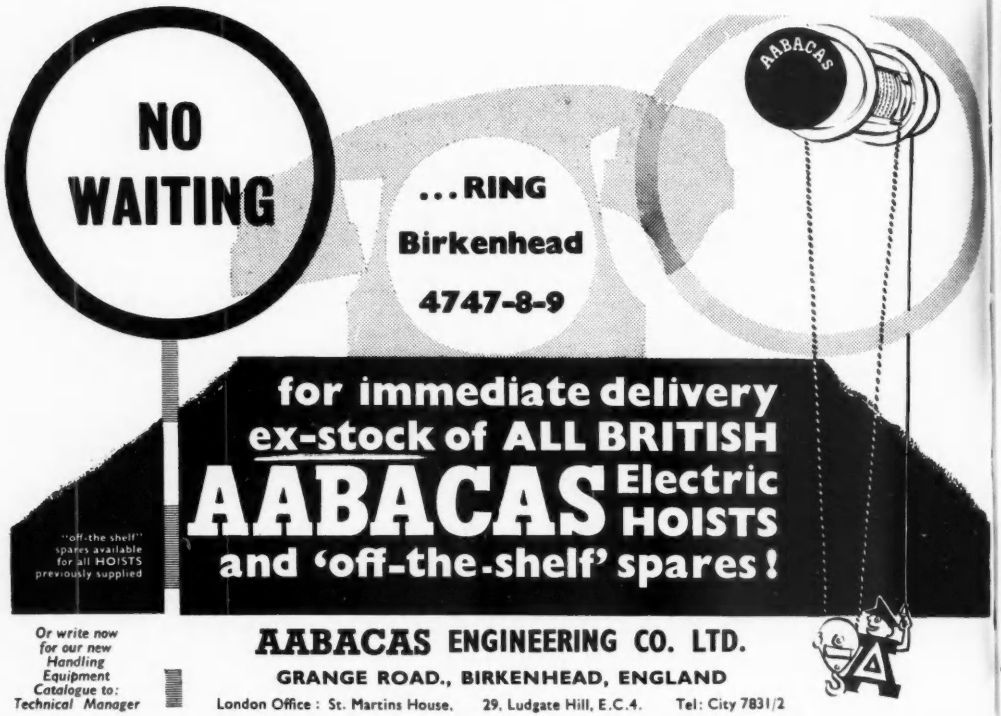
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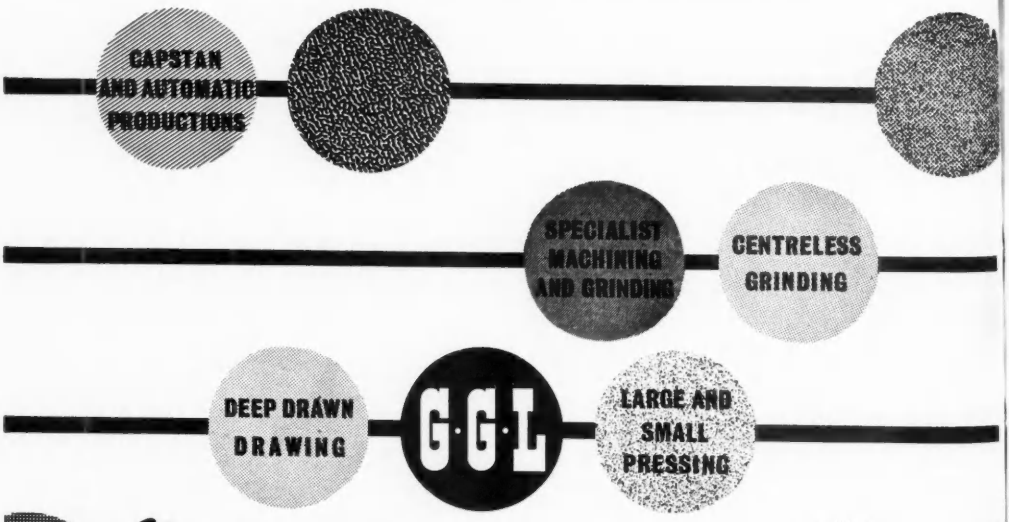
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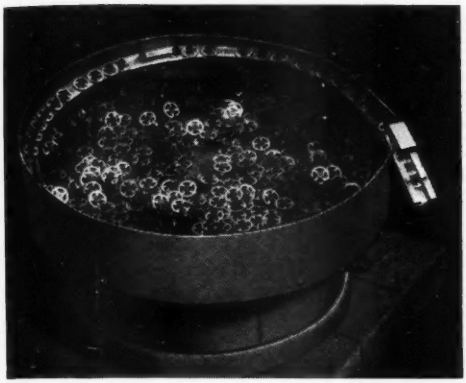

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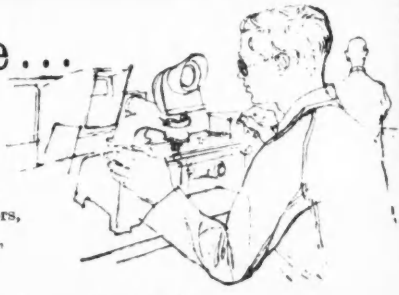

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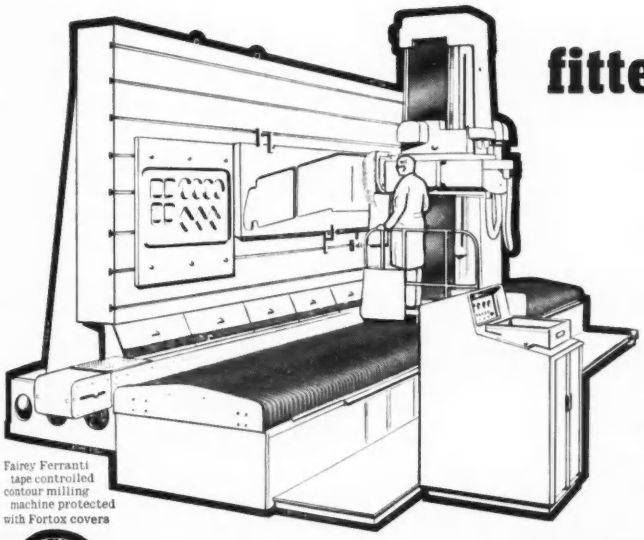

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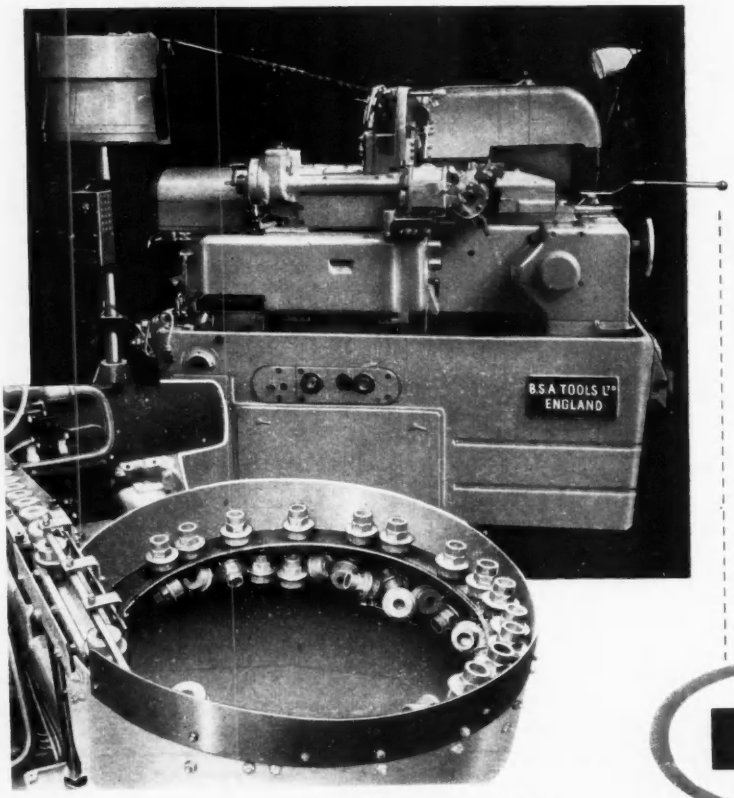
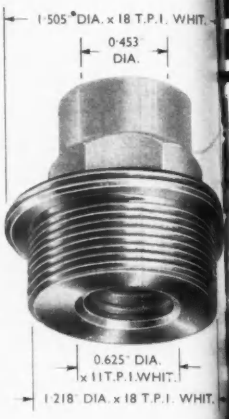
CENTEC MACHINE TOOLS, LTD. CENTEC WORKS HEMEL HEMPSTEAD HERTS *Tel: Boxmoor 584-5-6*





HOT BRASS STAMPING

Countersink. Form and combina
drill. Face and Chamfer. Exte
thread (2 diams.) and recess. T

SPINDLE SPEEDS: L.H. 1440 R
R.H. 582 R

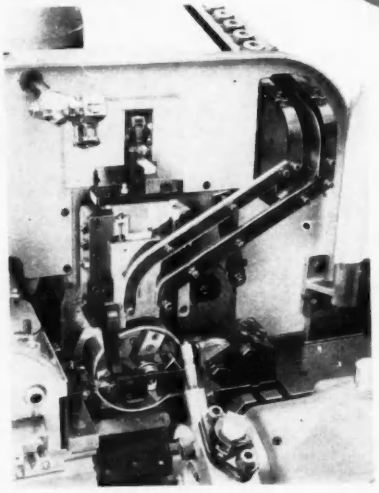
CYCLE TIME: 20 SECOND

B·S·A

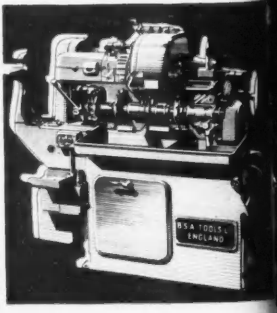
Top: B.S.A. No. 98L automatic arranged to produce the subject component is equipped with pneumatic workspindle-positioning attachment for stopping and locating the spindle with chuck jaws in a position of definite relation to tooling or, as in this example, the component.

Above: Vibratory hopper feeds the components to gravity chute.

Right: Air operated escapement releases components singly to a carrier on the third slide. Component is pushed into the chuck (positioned to receive the hexagon) by a ram in the turret. Thread cutting attachment is on front slide.



single spindle automatics



Made in several sizes and variations to suit the purpose

STAND 15
GRAND HALL

475

B.S.A. TOOLS LTD BIRMINGHAM 33 ENGLAND

Cables MADRICUT BIRMINGHAM TELEX 33-207

SOLE AGENTS GT. BRITAIN: BURTON GRIFFITHS & CO LTD MACKADOWN LANE BIRMINGHAM 33 TELEPHONE STECHFORD 3

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